REPORT

of the

SCIENCE SERVICE

DOMINION DEPARTMENT OF
AGRICULTURE

FOR THE YEAR ENDED MARCH 31

1947

REPRINTED FROM THE REPORT OF THE MINISTER OF AGRICULTURE
FOR THE YEAR ENDED MARCH 31, 1947

Published by the authority of the Hon. James G. Gardiner,
Minister of Agriculture, Ottawa, Canada

1M—10676—3:48

SCIENCE SERVICE

DIRECTOR

K. W. Neatby, B.S.A., M.S.A., Ph.D., F.R.S.C.

ASSOCIATE DIRECTORS

J. H. Craigie, A.B., M.Sc., Ph.D., D.Sc., F.R.S.C.

C. A. Mitchell, B.V.Sc., D.V.M., F.R.S.C.

ASSISTANT DIRECTOR

H. G. Crawford, B.S.A., M.S., F.R.E.S.

Research Adviser

W. E. van Steenburgh, O.B.E., B.A., M.A., Ph.D.

ASSISTANT TO DIRECTOR

J. A. Boyle, B.S.A.

CHIEFS OF DIVISIONS

Animal Pathology	C. A. Mitchell, B.V.Sc., D.V.M., F.R.S.C.
Bacteriology and Dairy Research	A. G. Lochhead, B.A., M.Sc., Ph.D., F.R.S.C.
Botany and Plant Pathology	J. H. Craigie, A.B., M.Sc., Ph.D., D.Sc., F.R.S.C.
Chemistry	C. H. Robinson, B.A., F.C.I.C.
Entomology	H. G. Crawford, B.S.A., M.S., F.R.E.S.
Plant Protection	W. N. Keenan

REPORT

OF THE

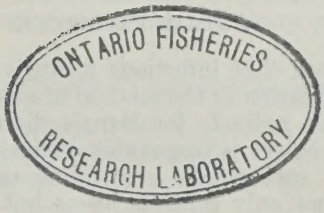
SCIENCE SERVICE

DOMINION DEPARTMENT OF AGRICULTURE

FOR THE

YEAR ENDED MARCH 31, 1947

CONTENTS



94878—2

SCIENCE SERVICE

The Science Service of the Dominion Department of Agriculture was established as a separate unit in 1938 when a general reorganization of the Department took place. Five existing divisions were combined at that time. The Plant Protection Division was added to the Service in 1942.

Science Service includes the research Divisions of Animal Pathology, Bacteriology and Dairy Research, Botany and Plant Pathology, Chemistry and Entomology, and the Division of Plant Protection. Centralized accounting and personnel services for these six units are maintained in the Administrative Division.

This report does not attempt to present in detail the results of investigations on the many projects now under way. Detailed reports have been published in scientific journals, and where further information is desired by research workers on particular projects, inquiries should be directed to the laboratories concerned. Publications giving detailed information for the use of farmers are available from the Publicity and Extension Division, Dominion Department of Agriculture, Ottawa.

The work of Science Service is directed toward the solution of practical problems of agriculture through scientific investigation. The Service is responsible for the maintenance and development of the National Collection of Insects, the Dominion Arboretum, and an economic herbarium. It deals with problems relating to the ravages of insect pests and diseases affecting plants and animals, the deterioration of plant and animal products through the invasion of fungi and bacteria, the nutritional requirements of plants and animals, and the chemistry and microbiology of soils, foods and dairy products. It carries out chemical and biological determinations required in the administration of various Dominion Acts and Regulations, and administers the Destructive Insect and Pest Act, including the inspection of imported and exported plants and plant products and the establishment of quarantine and control measures for introduced pests and diseases. The work in the various laboratories of the Science Service is co-ordinated with agricultural research undertaken by the Experimental Farms Service and other units of the Department, and with certain special research projects undertaken by the National Research Council and by universities and colleges of agriculture.

Some of the more important activities of the Divisions of Science Service during the past year are listed hereunder; more detailed statements are given in the Divisional reports which follow.

HIGHLIGHTS OF THE YEAR'S WORK

Animal Pathology

It has been confirmed that infectious mastitis may be treated successfully with penicillin. A modification of the method of dealing with herds is being tried.

Vaccination of adult animals for Bang's disease has not proved efficient, although vaccination of calves is reasonably successful.

A drug capable of successfully controlling caecal coccidiosis of chickens has been found. This not only controls losses but permits chickens to develop an immunity to the infection. It is believed that the widespread use of this chemical will in large measure eliminate serious losses from this disease.

The difficulties relating to the serological diagnosis of pullorum disease, and consequently its control, have been overcome. This has permitted the elimination of much of the pullorum infection which causes great economic loss.

Approximately 150,000 blood tests relating to the control of Bang's disease have been made.

Over 2,500,000 test doses of diagnostic agents have been distributed.

Bacteriology and Dairy Research

In the neutralization of cream for buttermaking accuracy in all steps was found to be essential to ensure uniform pH and satisfactory keeping quality.

A new method was developed for determining the setting time in cheddar cheesemaking.

The use of a sediment test on composite samples of cheese milk was found to save time and to provide a more accurate picture of incoming milk supplies.

A simple method of determining the acid degree of cheese fat was developed.

The rate and degree of acid development in the manufacture of cheddar cheese were found to be associated with rancid, unclean and fruit flavour defects.

The reducing-sugar content of frozen egg was found to bear no relation to the bacterial content.

Many commercial samples of frozen-pack vegetables were found to have unduly high bacteria counts. Studies were conducted on factors affecting the bacterial load on frozen products with a view to establishing standards and improving quality.

Resistance to manganese deficiency disease in oats was correlated with the numbers of manganese-oxidizing organisms in the rhizosphere of plants. The effectiveness of soil treatment by disinfectants was found to be related to the abundance of manganese-oxidizing and cellulose-decomposing organisms in the soil.

Studies on the bacterial equilibrium in soil indicated that one of the most characteristic effects of plant growth is the preferential stimulation of organisms requiring amino acids. The findings suggest an approach to the study of plant excretions and the physiology of the root system.

A new procedure was developed for a simple, rapid field test for the diagnosis of American foulbrood of bees.

Penicillin and notatin were found to be the most effective of many antibiotics studied in suppressing the growth of vegetative forms of organisms associated with foulbrood of bees, sulphonamides being less effective. Spores of *Bacillus larvae* were found to survive contact with relatively high concentrations of sulphathiazole.

Potassium was found to stimulate markedly the production of butylene glycol from starch by *Bacillus polymyxa* and to increase the diol:ethanol ratio.

Numerous actinomycetes isolated from soil showed antibacterial effect against both gram-negative and gram-positive organisms. Three different antibiotics were obtained in crude form for further study.

Quaternary ammonium compounds were found to compare favourably with hypochlorites as sanitizing agents for food and dairy plant equipment.

Botany and Plant Pathology

More attention than formerly is now being given to systematic botany. Valuable collections of *Agropyron* and *Potentilla* were made in Western Canada. Approximately 7,000 specimens were added to the herbarium, which now comprises 73,000 specimens.

Detailed data are now available on the percentage frequency of 325 species of weeds across Canada. Field surveys were made at Lake St. John, Que., and along the northwest frontier in Saskatchewan and Alberta.

An excellent demonstration was obtained at Alexandria, Ont., of the value of cereals, annual hay crops, and soybeans in the control of dodder.

Out of 4,800 seedlings of Russian dandelion from crosses made in 1945, two proved to have superior rubber content and high vigour.

The value of the Dominion Arboretum and Botanic Garden was increased by rearrangement of and additions to the collection. Some 3,000 lots of seed and plants were secured by exchange or purchase from other institutions.

Valuable additions were made to the Mycological Herbarium and the reference collection of pure cultures. A monograph of the genus *Dermea* in North America was published.

It was demonstrated that *Ascochyta Pisi,* the cause of a serious leaf and pod spot of peas, comprises at least three races.

The new potato variety, Teton, was found to be highly resistant, but not immune, to bacterial ring rot. Concern is expressed that it may prove to be a symptomless carrier.

The co-operative potato breeding program at Fredericton, N.B., has now advanced to the stage where a number of the most promising seedlings resistant to leaf roll, late blight, and scab, are being tested at selected stations across Canada.

The rate of spread of virus diseases was found to vary between and even within districts in Quebec, being extremely low in a few localities in the lower St. Lawrence.

Several strains of stone fruit varieties have been found to be free of virus infection. Stock of these will be propagated by Horticultural Experiment Station, Vineland, Ont., for distribution to the trade.

Investigations by the laboratory at Winnipeg, Man., indicate the increasing prevalence of strains of leaf rust capable of attacking wheats formerly resistant to the prevailing races. Progress has already been made in assisting the Dominion Laboratory of Cereal Breeding to develop varieties resistant to these strains.

A new laboratory was opened at Vancouver, B.C., to provide more adequate pathological assistance to the growers in the Coastal Region.

A crop of 34 million bulbs was inspected in 1946 by the staff of the laboratory at Saanichton, B.C., and further improvements were made in the treatments for bulbs.

Chemistry

Data from two major experiments added to those of previous years have established the reliability and reproducibility of digestible nutrient determinations used in the evaluation of feed stuffs.

A new technique for the evaluation of the protein of feeds for cattle and swine has been developed.

Part of the apparatus for studies on the use of stable isotopes to follow the course of feed utilization by animals has been assembled and tested.

A method has been evolved for the quantitative determination of the digestible nutrients consumed by sheep on pastures.

A new method to determine the setting time of cheddar cheese has been developed.

Determinations of ascorbic acid have assisted in the selection and development of tomato and apple varieties of consistently high vitamin C content.

Barn-cured hay was found to contain a higher protein and carotene content than field-cured hay.

A method involving a perchloric acid digestion followed by colour development with nitroso-R-salt was found most satisfactory for the determination of cobalt in plant materials.

The Plant Chemistry unit analysed 3,800 samples from co-operative experiments with the Experimental Farms Service. This required 15,100 separate determinations.

The use of plant tissue tests in fertilizer experiments with field crops was investigated. Significant increases in the concentration of nitrates, phosphates and potassium in the plants was brought about by fertilizer applications.

From the results obtained in a study of a method of "foliar diagnosis" as used by workers in Pennsylvania, it was concluded that the method was not applicable under the conditions of the experiment.

A greenhouse experiment with an ammoniated waste sulphite liquor product containing 3·7 per cent nitrogen showed that this material when compared with manure and commercial fertilizers was a highly satisfactory source of nitrogen for oats.

Dykeland soils were found to contain more boron, cobalt and copper, and less manganese, than upland soils.

In an investigation of vitamin A metabolism of sheep it was found that more than half of the dietary carotene could be recovered from the faeces.

Research on physiological response of chicks to vitamin D revealed several distinctive features of low-calcium and high-calcium rickets. The more rapid development of rickets in the first few days on a high-calcium diet suggests the possibility of developing a shorter assay method for vitamin D.

The parallel nature of log (dose) response curves obtained with several diets indicates that whereas the amount of vitamin D required to elicit a measurable response is a function of the diet, once the response has been obtained the efficiency of vitamin D is the same with all diets.

It is evident from the results of tests on the value of iodinated proteins for dairy cows that these thyrotropic substances should not be used indiscriminately.

The content of non-thyrotropic iodine in the diet and the route of thiouracil administration have a significant effect on the assay of thyrotropic substances with chicks.

The excretion of estrogens by pregnant mares was found to reach a maximum level after the sixth month of pregnancy.

A tattoo ink suitable for many breeds of livestock has been developed and applied at several areas in Ontario.

Entomology

DDT sprays and dusts were found to be the most effective treatment yet devised for control of the Colorado potato beetle. Almost equally good results were secured against other important pests of potatoes; aphids, leafhoppers, the potato flea beetle, and the tuber flea beetle.

DDT proved to be very effective against the purple-backed cabbage worm in Prince Edward Island, a pest for which no satisfactory control was known.

Benzene hexachloride (666) was found to be an extremely promising insecticide for the control of soil-inhabiting insects. Preliminary tests with wireworms, white grubs and root maggots were very satisfactory. The significance of this finding lies in the fact that good practical soil insecticides are rare.

Studies extending over a four-year period in apple orchards in Nova Scotia have revealed that sprays used in the control of apple scab definitely affect the abundance of oyster-shell scale. Fungicides containing sulphur destroy the parasites and predators that normally hold the scale in check and thus indirectly result in increased scale infestations; fungicides containing copper or a new organic material "Fermate", do not have this undesirable effect.

Benzene hexachloride is the most effective insecticide yet tested for the control of aphids in orchards.

Tests conducted in 1946 confirmed the previous findings that DDT is definitely the most effective material yet discovered for the control of the codling moth. However, further investigations are required before DDT can be recommended for general use in orchards. It is not effective against plant-infesting

mites, which are common in orchards, but it kills the natural enemies that ordinarily hold the mites in check. It also destroys the parasites that attack other pests of fruit such as the oriental fruit moth and scale insects.

Investigations begun in 1946 resulted in the isolation of some 40 different pathogenic organisms (fungi, bacteria, and viruses) from diseased spruce budworms collected in Canada. The possibility of control of this pest through artificial propagation and distribution of diseases will be studied in a special pathology laboratory now under construction. To supplement this investigation arrangements have been made with the Imperial Bureau of Biological Control to study and collect diseases affecting two closely allied budworms occurring in Central Europe.

Extensive tests of aircraft as a means of applying DDT sprays against forest insect pests, were continued. In co-operation with the Department of Lands and Forests of Ontario 40 square miles of forest were treated for the control of spruce budworm. The pest was almost entirely eliminated from the treated area and defoliation was very light. Satisfactory but less spectacular results were obtained against the hemlock looper in British Columbia where 19·5 square miles were sprayed in co-operation with the Provincial Forest Service and the industry.

During the year, a fish-packer type boat was purchased, rechristened *The J. M. Swaine,* refitted as a floating laboratory and used in the investigation of forest insect problems in otherwise inaccessible areas on the Pacific Coast.

A single treatment with DDT, benzene hexachloride, and magnesium oxide applied in late spring or early summer was found to give practically complete control of spider beetles in flour warehouses.

As a result of experimental work, magnesium oxide is now rather generally used in Canada for the protection of seeds of all types, both before and after packaging.

A coloured motion picture film on the control of spider beetles and other insects infesting flour was prepared and used in acquainting mill personnel with improved methods of control.

During the year, parasites were propagated and distributed to assist in the control of 15 different insect pests occurring in various parts of Canada and Newfoundland.

Further studies have confirmed previous findings that cattle sprayed with benzene hexachloride gain a large measure of protection from the dread paralysis tick.

In Western Canada, approximately 1,000,000 head of cattle were treated by cattle raisers in 1946 for the control of warble flies. After three years of treatment some ranchers have reduced the number of grubs per animal from an average of 30 to as low as 5 or 6.

During the year, type material of 46 species of insects was added to the Canadian National Collection by officers of the Systematic Entomology unit.

Plant Protection

Importations of 75,284,774 plant units, comprising 896,916 plants, 21,000,000 corms and cormels, and 53,387,858 bulbs, were inspected on arrival for insects and diseases.

Exports of 963,354 plants, 8,114,690 bulbs, corms and cormels, and 2,110 pounds of tree and miscellaneous seeds were inspected and certified before shipment to foreign countries.

Exports of plant products, consisting of nearly 25 million pounds of table stock potatoes, over 4 million bushels of apples, and approximately 9 million pounds of miscellaneous plant material, were certified as a requirement of the country concerned.

Imports of plant products, involving 2½ million containers, were also examined for infested or infected material.

The examination of passengers' baggage for plant material was carried out in co-operation with Customs officers at ocean ports and the bridgeheads at Niagara Falls and Windsor, Ont. At the request of the Customs, arrangements have been made for inspectors of this Division to be located at other important border crossing ports.

A total of 542 interceptions of insects and diseases were made on imported plants and plant products, none being new to Canada, except the durra stem borer *Sesamia cretica* Lederer, a serious pest of maize and sorghum in the Mediterranean area.

The inspection of boats, elevators, flour mills, processing plants, etc., was continued with the object of preventing serious damage and loss from insect pests to stored food products.

Large quantities of insect-infested broom corn and peanuts were successfully fumigated in box cars, under divisional supervision, before delivery to importers, and a variety of infested and infected commodities were also treated at the Divisional Fumigation and Research Laboratory in Montreal, Que., where investigational and experimental work is conducted continuously on various projects.

The main field projects carried out included an extensive survey for the European elm disease in Quebec and Ontario, including supervision of the removal and proper disposal of 1,342 infected trees found in the former province. An intensive Japanese beetle trapping and scouting campaign in 5 districts of Eastern Canada was conducted to determine spread and the necessity for soil treatment. A total of 754 beetles were taken in these operations, comparing favourably with 1,128 captured in 1945. A new outbreak discovered at Hamilton, Ont., involving about 17 acres, was soil treated.

Other co-operative field activities, included pre-harvest orchard surveys for apple maggot in Nova Scotia and Ontario; and Oriental fruit moth trapping, also grader inspection of fruit for scale insects, in British Columbia.

The acreage of potatoes entered for certification exceeded 1945 entries by over 17,000 acres; of which 82 per cent passed field inspections. Over 3¾ million bushels of Foundation and Foundation A seed were produced. There was an increase of 4 million bushels in total production over 1945.

Shipments from the 1946 crop, at March 31, 1947, totalled 3,262,876 bushels; from which 2¾ million bushels were exported, and over ½ million bushels were shipped to domestic markets.

An order for 70,000 long tons of table stock potatoes was received from the United Kingdom during the latter part of the year. The contract called for Prince Edward Island stock only. A large portion of this order was filled with potatoes that had passed field inspection for certification.

SCIENTIFIC PUBLICATION

ANIMAL PATHOLOGY

1. Heath, L. M. Tuberculin Studies XIII. Comparative potency determinations of tuberculin fractions obtained as a result of ultrafiltration and trichloracetic acid precipitation. Can. Jour. Comp. Med. 10:93. 1946.
2. Heath, L. M. and I. W. Moynihan. Tuberculin Studies XIV. Comparative activity of purified protein derived tuberculins prepared from different strains of tubercle bacilli. Can. Jour. Comp. Med. 10:102. 1946.
3. Konst, H. and P. J. G. Plummer. Studies on the toxicity of DDT for domestic and laboratory animals. Can. Jour. Comp. Med. 10:128. 1946.
4. Pullin, J. W. Tuberculous lesions of swine. I. Survey of lesions found in Eastern Canada. Can. Jour. Comp. Med. 10:159. 1946.

5. Bankier, J. C. Enzootic bovine haematuria (*Haematuria Vesicalis*) Experiments with the feeding of soil and the intravenous administration of soil extracts. Can. Jour. Comp. Med. 10:155. 1946.
6. Gwatkin, R. and P. J. G. Plummer. Toxicity of certain salts of sodium and potassium for swine. Can. Jour. Comp. Med. 10:183. 1946.
7. Gwatkin, R. Studies in pullorum disease. IX. Serological reactions of regular and variant types of *Salmonella pullorum*. Can. Jour. Comp. Med. 10:254. 1946.
8. Gwatkin, R. Studies in pullorum disease. X. Bacteriological examination of tissues from fowls exposed to infection with *Salmonella pullorum*. Can. Jour. Comp. Med. 10:277. 1946.
9. Gwatkin, R. Studies in pullorum disease. XI. The effect of sulfamerazine on artificially and naturally infected chicks. Can. Jour. Comp. Med. 10:283. 1946.
10. Bankier, J. C. Tuberculosis lesions of swine. II. Survey of lesions found in the Prairie Provinces especially in Alberta. Can. Jour. Comp. Med. 10:250. 1946.
11. Bankier, J. C. Avian tuberculosis. Observations on chickens infected by subcutaneous inoculation of tuberculous lesions from swine. Can Jour. Comp. Med. 10:164. 1946.
12. Bankier, J. C. Equine infectious anaemia. Attempted cross immunity experiments. Can. Jour. Comp. Med. 10:274. 1946.
13. Swales, W. E. The chemotherapy of caecal coccidiosis (*Eimeria tenella*). IV. Experiments on the use of chemotherapy during the immunizing exposure of chicks. Jour. A.V.M.A., 108:393. 1946.
14. Gwatkin, R. Studies in pullorum disease. XIV. Infection in the male and experiments in transmission to the female. Can. Jour. Comp. Med. 10:337. 1946.
15. Gwatkin, R. Studies in pullorum disease. XV. Trial modifications of tube and stained whole blood antigens. Can. Jour. Comp. Med. 11:18. 1947.
16. Gwatkin, R. Studies in pullorum disease. XVI. Disinfection of incubators with propylene and triethylene glycol. Can. Jour. Comp. Med. 11:52. 1947.
17. Plummer, P. J. G. Actinomycosis. Historical differentiation of actinomycosis and actinobacillosis. Can. Jour. Comp. Med. 10:331. 1946.
18. Walker, R. V. L. Rinderpest studies. Attenuation of the rabbit adapted strain of rinderpest virus. Can. Jour. Comp. Med. 11:11. 1947.
19. Pullin, J. W. An outbreak of mastitis caused by *Streptococcus pyogenes* and the effect of treatment with penicillin. Can. Jour. Comp. Med. 11:45. 1947.
20. Swales, W. E. New methods of controlling caecal coccidiosis in chickens. Can. Jour Comp. Med. 11:5. 1947.
21. Wickware, A. B. The differential blood picture in chickens before and after administration of embryonated eggs of *Heterakis gallinae* with notes on pathogenicity. Can. Jour. Comp. Med. 11:78. 1947.

BACTERIOLOGY AND DAIRY RESEARCH

1. Katznelson, H. The "rhizosphere effect" of mangels on certain groups of soil microorganisms. Soil Sci. 62:343-354. 1946.
2. Jones, A. H. and M. E. Pierce. Quality control effects improvement in Canadian dehydrated vegetables. Food in Canada. 6:30-32. 1946.
3. Katznelson, H. Studies with *Bacillus polymyxa*. IV. Nitrogen requirements in relation to 2, 3-Butanediol production from starch. Can. J. Res. C, 24:99-108. 1946.
4. Johns, C. K. Sanitation in the Canadian egg drying industry. Food in Canada. 6:19-21 1946.
5. Timonin, M. I. Activity of patulin against *Ustilago tritici* (Pers.). Jen. Sci. Agr. 26:358. 1946.
6. Timonin, M. I. Effect of temperature on brown root-rot soil. The Lighter. 16:12-15 1946.
7. Gitterman, C. O. Relation of mould count to quality. Canadian Food Packer. 17:35. 1946.
8. Johns, C. K. and H. V. Pritchard. Quaternary ammonium compounds as preservatives for milk. Can. Pub. Health J. 37:500-504. 1946.
9. White, A. H. The use of indicator paper to determine the pH of butter. Canadian Dairy & Ice Cream J. 25:23-25, 64, 66. 1946.
10. Johns, C. K. Studies comparing the sanitizing efficiencies of hypochlorites and quaternary ammonium compounds. Can. J. Res., F. 25: 76-91. 1947.
11. Hood, E. G. and I. Hlynka. Use of composite milk samples for making sediment tests Can. Dairy and Ice Cream J. 25:27-28. 1946.

12. Katznelson, H. Nutritional requirements of *Streptococcus apis*. J. Bacteriology. 53 : 125. 1947.
13. Katznelson, H. and A. G. Lockhead. Nutritional requirements of *Bacillus alvei* and *Bacillus para-alvei*. J. Bacteriology. 53 : 83-88. 1947.
14. Hlynka, I., E. G. Hood and C. A. Gibson. The influence of acidity on the development of lipolytic flavour defects in cheddar cheese. Sci. Agr. 27 : 50-56. 1947.
15. Lochhead, A. G., and R. H. Thexton. Qualitative studies of soil micro-organisms. VII. The "rhizosphere effect" in relation to the amino acid nutrition of bacteria. Can. J. Res., C. 25:20-26. 1947.
16. Katznelson, H. and A. G. Lochhead. Rapid field tests for the diagnosis of American foulbrood of bees. Sci. Agr. 27:67-71. 1947.
17. Lochhead, A. G. and R. H. Thexton. Growth and survival of bacteria in peat. I. Powdered peat and related products. Can. J. Res., C. 25:1-13. 1947.
18. Lochhead, A. G. and R. H. Thexton Growth and survival of bacteria in peat II. Peat pellets. Can. J. Res., C. 25:14-19 1947
19. Jones, A. H. and M. E. Pierce. Quality control of canned tomato products. Can. Food Packer. 18 : 19-23. 1947.
20. Katznelson, H. Substitution of thiamine by certain amino acids in the nutrition of *Bacillus para-alvei*. J. Biol. Chem. 167 : 615-616. 1947.
21. Landerkin, G. B. The isolation of antibiotic actinomycetes. Can. J. Pub. Health. 38:90. 1947.
22. Johns, C. K. A method for assessing the sanitizing efficiency of quaternary ammonium and hypochlorite products. Can. J. Pub. Health. 38 : 93. 1947.
23. Jones, A. H. and M. E. Pierce The significance of micro-organisms in frozen fruits and vegetables Can. J. Pub. Health. 38 : 96. 1947.

Botany and Plant Pathology

1. Newton, Margaret and T. Johnson. Physiologic races of *Puccinia graminis Tritici* in Canada, 1919 to 1944. Can. J. Res., C. 24 : 26-28. 1946.
2. Gorham, P. R. Investigations on rubber-bearing plants, II. Carbohydrates in the roots of *Taraxacum kok-saghyz* Rod. Can. J. Res., C. 24 : 47-53. 1946.
3. Johnson, T. The effect of DDT on the stem-rust reaction of Khapli wheat. Can. J. Res., C. 24 : 23-25. 1946.
4. Willison, R. S. Peach blotch. Phytopathology 36 : 273-276. 1946.
5. Greaney, F. J. Influence of time, rate and depth of seeding on the incidence of root-rot in wheat. Phytopathology 36 : 252-263. 1946.
6. Bier, J. E. and R. E. Foster. The relation of research in forest pathology to the preparation of forest inventories. I. Suggested aids for cruising overmature stands of Sitka spruce on the Queen Charlotte Islands. B.C. Lumberman 30 : 38-40. 1946.
7. Bier, J. E. and R. E. Foster. The relation of research in forest pathology to the utilization of overmature timber. II. The significance of conk rot in Sitka spruce on the Queen Charlotte Islands. B.C. Lumberman 39 : 51-52. 1946.
8. Minshall, W. H. Eradication of poison ivy (*Rhus radicans* L.). Experiments with sodium chlorate, sodium chloride and two petroleum oils. Sci. Agr. 26 : 183-193. 1946.
9. Chamberlain, G. C. Sour cherry troubles. Can. Hort. and Home 69 : 125-126. 1946.
10. Johnson, T. and Margaret Newton. Specialization, hydridization, and mutation in the cereal rusts. Botanical Review 12 : 337-392. 1946.
11. Moore, Raymond J. Investigations on rubber bearing plants. III. Development of normal and aborting seeds in *Asclepias syriaca* L. Can. J. Res., C. 25 : 55-65. 1946.
12. Moore, Raymond J. Investigations on rubber bearing plants. IV. Cytogenetic studies in *Asclepias* (Tourn.) L. Can. J. Res. C, 24 : 66-73. 1946
13. Ledingham, R. J. The effect of seed treatment and dates of seeding on the emergence and yield of peas. Sci. Agric. 26 : 248-257. 1946.
14. Groves, J. W. and A. J. Skolko. Notes on seed-borne fungi. IV. Acremoniella, Chlamydomyces, and Trichocladium. Can. J. Res., C. 24 : 74-80. 1946.
15. Bier, J. E. The relation of research in forest pathology to the utilization of overmature timber. II. The significance of brown pocket rot in Sitka spruce on the Queen Charlotte Islands. B.C. Lumberman 30 : 54-55. 1946.
16. Raciot, H. N. Practical methods for control of common scab of potatoes. Proceedings of annual meeting of Ontario Crop Improvement Association. 1946.
17. Savile, D. B. O. A rapid freehand sectioning method for leaves. Stain Tech. 21 : 99-102. 1946.

18. Savile, D. B. O. A new species of Stagonospora on Ambrosia. Mycologia 38 : 453-454. 1946.

19. Groves, J. Walton. North American species of Dermea. Mycologia 38 : 351-431. 1946.

20. Senn, H. A. and M. N. Zinck. Additional records of old field birch, *Betula populifolia* Marsh., in Ontario. Can. Field Nat. 60 : 92-94. 1946.

21. Senn, H. A. A bibliography of Canadian plant geography. VII. Additions: author, geographic and subject indices for the period 1635-1935. Trans. Roy. Can. Inst. 26 (Pt. 1, No. 55) : 9-151. 1946.

22. Bier, J. E. and R. E. Foster. The relation of research in forest pathology to the preparation of forest inventories. II. The possibility of obtaining net volumes by grade when cruising overmature stands of Sitka spruce on the Queen Charlotte Islands. B.C. Lumberman. July 1946.

23. Newton, Wm. and J. E. Bosher. Growth stimulation in iris bulbs by urea. Sci. Agric. 26 : 300-302. 1946.

24. Newton, Wm. and J. E. Bosher. The longevity of *Phoma Betae* in garden beet seed. Sci. Agric. 26 : 305-306. 1946.

25. Newton, Wm. The growth of *Sclerotinia sclerotiorum* and *Alternaria Solani* in simple nutrient solutions. Sci. Agric. 26 : 303-304. 1946.

26. Bier, J. E., R. E. Foster and P. J. Salisbury. Decay of Sitka spruce on the Queen Charlotte Islands. Dominion Department of Agriculture Publication 783. Technical Bulletin 56. 1946.

27. Saville, D. B. O. *Entyloma fuscum* and related smuts attacking Papaveraceae. Can. J. Res., C. 24 : 109-114. 1946.

28. Russell, R. C. Testing seed for smut spores as an aid in controlling cereal smuts in Saskatchewan. Sci. Agric. 26 : 372-380. 1946.

29. Bier, J. E. and Mildred K. Nobles. Brown pocket rot of Sitka spruce. Can. J. Res., C. 24 : 115-120. 1946.

30. McCallum, A. W. The occurrence of Dutch Elm disease in Canada. Forestry Chron. 22 : 203-209. 1946.

31. Groh, H. and E. G. Anderson. More *Impatiens Roylei* in Canada. Can. Field Nat. 60 : 116. 1946.

32. Johnson, T. and Margaret Newton. The occurrence of new strains of *Puccinia Triticina* in Canada and their bearing on varietal reaction. Sci. Agr. 26 : 468-478. 1946.

33. Lachance, R. O. Quelques considérations sur les arrosages des tomates. Agriculture (Prov. Que.) 3 : 3-8. 1946.

34. Pelletier, Real. Les nouveaux fongicides. Agriculture 3 : 2-7. 1946.

35. Cormack, M. W. *Sclerotinia sativa* and related species as root parasites of alfalfa and sweet clover in Alberta. Sci. Agr. 26 : 448-459. 1946.

36. Miller, J. J. Cultural and taxonomic studies on certain Fusaria. II. The taxonomic problem in *Fusarium* with particular reference to section *Elegans*. Can. J. Res., C. 24 : 213-223. 1946.

37. Miller, J. J. Cultural and taxonomic studies on certain Fusaria. I. Mutation in culture. Can. J. Res., C. 24 : 188-212. 1946.

38. Buckland, D. C. Investigations of decay in western red cedar in British Columbia. Can. J. Res., C. 24 : 158-181. 1946.

39. Cherewick, W. J. A method of establishing rust epidemics in experimental plots. Sci. Agr. 26 : 548-551. 1946.

40. Minshall, W. H. Eradication of poison ivy (*Rhus radicans* L.). II. Preliminary results with 2,4-dichlorophenoxyacetic acid. Sci. Agr. 26 : 662. 1946.

41. Lott, T. B. and W. R. Foster. "Little cherry", a virus disease. Sci. Agric. 27 : 1-6. 1947.

42. Richardson, J. K. Tests with potato vine killers in Ontario. Ont. Crop Improv. Assoc. Potato section. Annual meeting. Addresses and Proc. 1947.

43. Callbeck, L. C. Killing potato tops with chemicals. Ont. Crop Improv. Assoc. Potato section. Annual meeting. Addresses and Proc. 1947.

44. Bier, J. E. and D. C. Buckland. Relation of research in forest pathology to the management of second growth forests. I. *Poria Weirii* root-rot, an important disease affecting immature stands of Douglas fir. B.C. Lumberman 31 : 49-51. 1947.

45. Miller, J. J., L. W. Koch and A. A. Hildebrand. A comparison of cultural methods for the maintenance of certain economic fungi. Sci. Agr. 27 : 74-80. 1947.

46. Tyner, L. E. Studies on ring rot of potatoes caused by *Corynebacterium sepedonicum*. Sci. Agr. 27 : 81-85. 1947.

47. Newton, W. and C. Lines. The dusting of cut potato tubers as a preventative against Pythium rot. Sci. Agr. 27 : 72-73. 1947.
48. Hildebrand, A. A. and L. W. Koch. Soybean diseases in Ontario and effectiveness of seed treatment. Phytopathology 37 : 111-124. 1947.
49. Moore, R. J. Investigations on rubber-bearing plants. V. Notes on the flower biology and pod yield of *Asclepias syriaca* L. Can. Field Nat. 61 : 40-46. 1947.
50. Minshall, W. H. First dates of anthesis for four tests at Ottawa, Ontario, for the period of 1936-1945. Can. Field Nat. 61 : 56-59. 1947.

CHEMISTRY

1. Allen, C. E. Tattoo identification of sheep and horses. Sci. Agr. 26 : 271-274. 1946.
2. Campbell, J. A. and A. R. G. Emslie. Studies on the chick assay for vitamin D. V. A comparison of the A.O.A.C. and B.S.I. diets and feeding periods. Poult. Sci. 26 : 255-261. 1947.
3. Campbell, J A. and A. R. G. Emslie. Variability in chick growth data. Poult. Sci. In press.
4. Hiscox, Dorothy J. Determination of cobalt in plant materials. Sci. Agr. 27 : 136-141. 1947.
5. Hlynka, I. and E. G. Hood. Rating the acid producing ability of starters for cheddar cheese-making. Jour. Dairy Sci. In press.
6. Hlynka, I. and E. G. Hood. Brown discoloration in malted process cheese. Food Research. In press.
7. Johnston, F. B., J. R. W. Miles and H. Hill. Rapid determination of potassium, calcium and magnesium in plant tissues. Proceedings of the Inter. Congress of Pure and Applied Chemistry. In press.
8. Migicovsky, B. B. and A. R. G. Emslie. Interaction of calcium, phosphorus and vitamin D. I. Influence of dietary calcium and phosphorus on body weight and bone ash of chicks. Archives of Biochem. In press.
9. Migicovsky, B. B. and A. R. G. Emslie. Interaction of calcium, phosphorus and vitamin D. II. Rachitogenic index. Archiv. of Biochem. In press.
10. Robinson, C. H. and I. Hlynka. Calcium content of fluid milk. Can. Pub. Health Jour. 38. 1947.
11. Watson, C. J., J. W. Kennedy, W. M. Davidson, C. H. Robinson and G. W. Muir. Digestibility studies with swine. II. The digestibility of grains and vegetable protein concentrates at different stages of the growing and fattening period. Sci. Agr. 26 : 552-559. 1946.
12. Watson, C. J., J. W. Kennedy, W. M. Davidson and E. B. Fraser. Digestibility studies with swine. III. Digestibilities of some animal by-products, peas and barley. Sci. Agr. 27 : 165-170. 1947.
13. Watson, C. J., J. W. Kennedy, W. M. Davidson, C. H. Robinson and G. W. Muir. Digestibility studies with ruminants. X. Relative associative effects of the roughages, timothy and alfalfa. Sci. Agr. 27 : 175-182. 1947.
14. Watson, C. J., J. W. Kennedy, W. M. Davidson, C. H. Robinson and G. W. Muir. Digestibility studies with ruminants. XI. The effect of the nutritive ratio of a ration upon its digestibility by cattle. In press.

ENTOMOLOGY

1. Beall, G. Seasonal variation in sex proportion and wing length in the migrant butterfly, *Danaus plexippus* L. (Lepidoptera Danaidae). Trans. Roy. Ent. Soc. Lond. 97 : 337-353. 1946.
2. Bird, R. D. The sweet clover weevil, *Sitona cylindricollis* Fahr. Can. Ent. LXXIV : 5-11. 1947.
3. Boyce, H. R. Larvae of *Spilonota ocellana* (D. & S.) used to provision nests of eumenid wasp. 76th Ann. Rept. Ent. Soc. Ont. (1945) : 35-37. 1946.
4. Brooks, A. R. A revision of the North American species of *Lischenaultia* Sens. Can. Ent. LXXVIII : 169-182. 1946.
5. Brown, N. R. Studies on parasites of the spruce budworm, *Archips fumiferana* (Clem.) (1) life history of *Apanteles fumiferanae* Viereck. Can. Ent. LXXVIII : 121-129. 1946.
6. Brown, N. R. Studies on parasites of the spruce budworm, *Archips fumiferana* (Clem.) (2) life history of *Glypta fumiferanae*. Can. Ent. LXXVIII : 138-147. 1946.
7. Brown, W. J. Notes on some species of *Canthon* and *Dichelonyx* larvae. Can. Ent. LXXVIII : 104-109. 1946.

8. Burnett, T. Biological control of greenhouse insects in Canada. 29th Rept. Que. Soc. Prot. Plants (1943-1944) : 84-86. 1946.
9. Dustan, G. G. Effect of temperature on toxicity of D.D.T. Can. Ent. LXXIX : 1-4. 1947.
10. Farstad, C. W. and A. W. Platt. The reaction of barley varieties to wheat stem sawfly attack. Sci. Agr. 26 : 216-224. 1946.
11. Farstad, C. W. and A. W. Platt. The reaction of wheat varieties to wheat stem sawfly attack. Sci. Agr. 26 : 234-247. 1946.
12. Fox, C. J. and J. P. Perron. Report on a potato leafhopper control experiment at Ottawa with DDT and copper sprays. 76th Ann. Rept. Ent. Soc. Ont. (1945) : 27-31. 1946.
13. Freeman, T. N. A new general assignment for *Archips fumiferana* Clemens, the spruce budworm (Lepidoptera, Tortricidae). (In press).
14. Freeman, T. N. The external anatomy of the spruce budworm *Choristoneura fumiferana* Clem. (Lepidoptera, Tortricidae). (In press).
15. Freeman, T. N. Book notice—The butterflies of Washington. (In press).
16. Fulton, H. G. Natural control of the European pea moth, *Laspeyresia nigricana*, at Sumas Prairie, B.C. Proc. Ent. Soc. B.C. 43 : 25-27. 1947.
17. Gregson, J. D. Feeding periods prerequisite to the mating of *Dermacentor andersoni*. Proc. Ent. Soc. B.C. 43 : 3-6. 1947.
18. Gregson, J. D. Benzene hexachloride ("666") as an acaricide. Can. Ent. LXXVIII : 201-202, 1946.
19. Hammond, G. H. White grub infestations in Ontario, 1945. 76th Ann. Rept. Ent. Soc. Ont. (1945) : 15-18. 1946.
20. Handford, R. H. The identification of nymphs of the genus *Melanoplus* of Manitoba and adjacent areas. Sci. Agr. 26 : 147-180. 1946.
21. Handford, R. H. The use of DDT in cutworm control. (In press.)
22. Leech, H. B. Crow eating Serica beetles (Coleoptera Scarabaeidae). Can. Ent. LXXIX : 4. 1947.
23. Leech, H. B. Collecting in southern British Columbia: finding of the water beetle, *Deronectes spenceri*. Can. Ent. LXXVIII : 198-200. 1946.
24. Leech, H. B. List of some *Philonthus* from British Columbia. Proc. Ent. Soc. B.C. 43 : 23-24. 1947.
25. Leech, H. B. Local abundance of the wasps, *Chlorion atratum* and *Megastizus unicintus*. Proc. Ent. Soc. B.C. 43 : 32. 1947.
26. Maltais, J. B. Enquête sur les pucerons de la pomme de terre dans Quebec. 29th Rept. Que. Soc. Prot. Plants (1943-1944) : 110-113. 1946.
27. Marshall, James and H. F. Olds. The pear psylla in British Columbia. Proc. Ent. Soc. B.C. 43 : 1-3. 1947.
28. McDunnough, J. Notes on the Ericoides-Duplicis group of the genus *Coleophora*. Can. Ent. LXXVIII : 147-153. 1946.
29. McDunnough, J. The species of the Truncata group of the genus *Dysstroma*. Can. Ent. LXXVIII : 71-78. 1946.
30. McDunnough, J. New North American Eupithecias, II (Lepidoptera, Geometridae). Can. Ent. LXXVIII : 86-89. 1946.
31. McDunnough, J. Gracillariid studies. Can. Ent. LXXVIII : 91-95. 1946.
32. McDunnough, J. Notes on Robinia feeding phycitid larvae. Can. Ent. LXXVIII : 109-110. 1946.
33. McDunnough, J. The agrotid genus *Agrotiphila* Grt. and its genotype (Lepidoptera). In press.
34. McGuffin, W. C. Larvae of some Canadian geometrids. Can. Ent. LXXVIII : 160-162. 1946.
35. Peck, O. and A. B. Gahan. Notes on some Ashmeadian genotypes in the hymenopterous super-family Chalcidoidea. Jour. Wash. Acad. Sci. 36 : 314-317. 1946.
36. Peck, O. and J. L. Bolton. Alfalfa seed production in northern Saskatchewan as affected by bees—with a report on means of increasing the population of native bees. Sci. Agr. 26 : 388-418. 1946.
37. Pickett, A. D., N. A. Patterson, H. T. Stultz and F. T. Lord. The influence of spray programs on the fauna of apple orchards in Nova Scotia. Sci. Agr. 26 : 590-600. 1946.
38. Richmond, H. A. Current trend of the western hemlock looper (*Lambdina lugubrosa*) in the coastal forests of British Columbia. Proc. Ent. Soc. B.C. 43 : 33-35. 1947.
39. Salt, R. W. Moisture relationships of the wheat stem sawfly (*Cephus cinctus Nort.*) I. Some effects of desiccation. Sci. Agr. 26 : 622-630. 1946

40. Salt, R. W. Moisture relationships of the wheat stem sawfly (*Cephus cinctus Nort.*) II. Some effects of contact moisture. Sci. Agr. 26 : 631-639. 1946.
41. Salt, R. W. and H. G. James. Low temperature as a factor in the mortality of eggs of *Mantis religiosa*. In press.
42. Shewell, G. E. The male of *Diachlorus ferrugatus* (Fabr.) (Diptera, Tabanide). In press.
43. Smith, R. W. Parasitism of grasshoppers in Canada. 29th Rept. Que. Soc. Prot. Plants (1943-1944) : 114-115. 1946.
44. Smith, R. W. and W. W. A. Stewart. A useful cage for sampling field populations of grasshoppers. 76th Ann. Rept. Ent. Soc. Ont. (1945) : 32-35. 1946.
45. Twinn, C. R. A note on the occurrence and distribution of *Anopheles* mosquitoes in Canada. 29th Rept. Que. Soc. Prot. Plants (1943-1944) : 55. 1946.
46. Twinn, C. R. A summary of the more important insect conditions in Canada in 1945. 76th Ann. Rept. Ent. Soc. Ont. (1945) : 49-55. 1946.
47. Twinn, C. R. DDT and its application in veterinary medicine. Can. Jour. Comp. Med. & Vet. Sc. 10 : 301-315. 1946.
48. Twinn, C. R. The newer insecticides, repellents and rodenticides of value in the field of public health. Sci. Agr. 27 : 97-104. 1947.
49. White, R. M. Preliminary observations on some effects of artificial defoliation of wheat plants. Sci. Agr. 26 : 225-229. 1946.
50. Wilkes, A. The introduction of insect parasites of the spruce budworm *Archips fumiferana* Clem. into Eastern Canada. Can. Ent. LXXVIII : 82-86. 1946.
51. Wishart, G. Laboratory rearing of *Macrocentrus gifuensis* Ashm., a parasite of the European corn borer. Can. Ent. LXXVIII : 78-82. 1946.
52. Wishart, G. Observations on the emergence of *Macrocentrus gifuensis* Ashm. Can. Ent. LXXVIII : 162-168. 1946.
53. Wishart, G. and H. G. James. Notes on the anopheline mosquitoes of the Kingston, Trenton and Peterborough areas. 76th Ann. Rept. Ent. Soc. Ont. (1945) : 39-48. 1946.

PLANT PROTECTION

1. Baribeau, B. and R. Gagnon. L'indexage des pommes de terre de semence. Agriculture, 3 : 123-135. 1946.
2. Baribeau, B. Seed potato districts and virus diseases in Que. Sci. Agr. 26 : 654-661. 1946.
3. Baribeau, B. Possibilities d'amelioration, d'organisation et d'extension de la production des pommes de terre de semence. Agriculture, 4 : 13-26. 1947.
4. Hicks, S. D. Additional notes on Coleoptera taken in Essex Co. and southern Ontario, Canada. Can. Ent. In print.
5. Monro, H. A. U. Methyl bromide fumigation of plant products in steel barges and the holds of ships. Sci. Agr. In print.
6. Monro, H. A. U. and R. Delisle. Methyl bromide fumigation of plant products in railroad freight cars. Pests and Their Control. Jour. of the pest control industry, Kansas City, Mo. Sept. 1946.

DIVISION OF ANIMAL PATHOLOGY

The Division of Animal Pathology is composed of a central institute (Animal Diseases Research Institute) situated at Hull, Quebec, and four branch laboratories located as follows: Saanichton, B.C., Lethbridge, Alta., Macdonald College, Que., and at the Central Experimental Farm, Ottawa.

The field of animal pathology, like other fields of experimental medicine, has gone rapidly through a stage of transition and specialties have developed. For this reason, in addition to research officers, the Division is divided into a number of units each being in charge of a specialist in the particular field. In this way the greatest amount of concentrated effort can be brought to bear and the services of highly qualified and experienced investigators co-ordinated to attack a problem more vigorously.

The work of the Division may be classified under three headings—Research, Services, and Manufacture of Biological Products.

Research

Infectious Mastitis of Cattle.—Infectious mastitis of cattle is one of the causes of great economic loss to the cattle industry. In addition it causes the loss of a very considerable amount of human food. A long-term project in this field has culminated in the discovery that penicillin is extraordinarily efficient in the treatment of this disease. If combined with known preventive and sanitary measures it can, in large measure, eliminate the disease from herds. Work is being carried on to demonstrate the most efficient and economical method of application of penicillin. It has been discovered that in general where the disease is extensive, the treatment of every animal in a herd whether symptoms are present or not is the most economical means. However, each herd is a separate unit requiring consideration and judgment, and the disease is not one which at present can be readily mastered with lay help only. It will require for some time to come, perhaps always, the interpretation and experienced judgment of a well trained veterinarian to put the methods into operation.

Infectious Abortion (Bang's Disease) of Cattle.— Experiments commenced a number of years ago have yielded a considerable amount of information. In general it may be said that the results indicate that vaccination of the calf induces a considerable degree of protection. This is to be distinguished, however, from complete immunity. Vaccination of adults is less effective, and apparently vaccination in the face of a "storm" of abortion is useless. This indicates the necessity of using vaccination as a supplemental measure to existing controls with the purpose of finally eliminating the disease from the country. When public opinion demands that the work be conducted on an area basis, the methods demonstrated will be capable of application systematically rather than in the present haphazard manner.

Coccidiosis of Chickens.—One of the two most destructive diseases of chickens is caecal coccidiosis. The annual loss from this disease has been tremendous for years past and different remedies and methods of control have been only partially successful. A large-scale experiment introduced two years ago resulted in the discovery of a drug which makes possible the complete control of this disease. Control of coccidiosis involves the bird having a slight attack which confers subsequent immunity. If attacks are completely prevented by chemical or other means the flock is always susceptible. The action of the drug limits the disease to a non-clinical form so that all birds become immune without costly losses. Based on this discovery, three systems have been recommended which will permit persons to raise chickens without loss from caecal coccidiosis.

Pullorum Disease of Chickens.—The other great cause of losses in chickens is pullorum disease. Attention was directed to this previously when it was pointed out that a special type of organism had developed which could not be discovered by known methods of test. Consequently a fundamental study had to be undertaken to discover the particular changes which have been taking place in the organism which caused it to evade detection by ordinary means. It was demonstrated that the organism had a different biochemical composition than strains known previously. Scientists viewed this with some skepticism, but within this year the highest authorities in different parts of the world have confirmed the work.

The discovery of the nature of the particular form of micro-organism has made possible an accurate diagnosis of the disease when it exists in the non-clinical form in adult fowls from which it is transferred to chickens. Because of this the disease during this last season has in large measure disappeared from Canadian flocks. The saving which this will bring to the poultry industry is great.

Transmissible Leucosis of Fowl.—Studies have continued on this disease but only slight progress has been made. This is mainly due to the effort which has necessarily been put into solving the two problems already mentioned and which has left little time to concentrate on this particular infection.

Eimeria Acervulina *Infection of Domestic Fowl.*—The importance of this infection was unknown because it has been complicated by a number of different factors which preclude assessing it. An extensive study was organized in which a considerable number of birds were employed and under the most rigid conditions of isolation. It was found possible to raise chickens free from all other infections and to carry this one as a single disease entity, thus permitting determining its importance. The results demonstrate that *Eimeria acervulina* is capable of retarding the development of the bird, bringing about a degree of anemia, but that mortality is very low.

Rhinitis of Swine.—Although this disease has been studied intensively during the year, no information has become available indicating the nature of the infective agent or the manner in which it is transferred from one animal to another. In fact under experimental conditions, it has been found impossible to bring about experimental infections. Re-orientation of the experimental approach is being made and the services of different unit heads are being enlisted to discover if possible some lead to the solution of this problem.

Tuberculin Studies.—Although tuberculin has been in use for many years, problems still arise concerning it. Animals exported from Canada must pass the test which is conducted in the country of destination. This has aroused interest in connection with the types of tuberculin employed in various countries. It has been discovered that the type used in some countries has a somewhat wider coverage and sensitivity than is desirable and for this reason experiments have been undertaken to develop a tuberculin which is sufficiently sensitive for the purpose intended without the wide coverage which is the property of some other tuberculins. A great deal of work has been carried on along these lines and there now appears to be a possibility of developing an improved type of biological agent.

Services

Laboratory services are given to veterinarians, physicians, livestock owners and others. These services are made up of a considerable number of diverse types of work, post-mortem examinations, serological and bacteriological tests, parasitological and pathological studies, and testing for other departments of substances presented for registration such as raticides and drug preparations for the control of parasites. A condensed summary is given of these examinations—

Serological Tests for Bang's Disease	
Animal Diseases Research Inst., Hull, Que	149,942
Veterinary Research Laboratory, Lethbridge, Alta.	3,455
Pathological Laboratory, Saanichton, B.C.	3,757
Serological Tests for Pullorum Disease	
Veterinary Research Laboratory, Lethbridge, Alta.	244
Poultry Pathology Laboratory, Ottawa	7,085
Miscellaneous Specimens and Post-Mortem Examinations	
Animal Diseases Research Inst., Hull, Que	443
Veterinary Research Laboratory, Lethbridge, Alta.	263
Pathological Laboratory, Saanichton, B.C.	319
Poultry Pathology Laboratory, Ottawa	998

Manufacture of Biological Products

Biological products are made on a large scale, and are issued to Veterinary Inspectors, to other Departments, and to persons engaged in the diagnosis or control of animal diseases. The following is a summary of the products distributed during the year—

Tuberculin		1,843,424 doses
Mallein		30,142 doses
Johnin		1,710 doses
Brucella abortus antigen	tube test	37,962 test doses
	rapid test	6,500 test doses
Pullorum disease		575,500 test doses

DIVISION OF BACTERIOLOGY AND DAIRY RESEARCH

Dairy Research

Milk.—With the resazurin test for the bacteriological quality of milk now officially recognized as one of the Standard Methods, it is being widely adopted by both plant and official control laboratories throughout Canada. Work with this test during the past year has been largely confined to the checking of batches of dye to make certain that each new batch of standardized tablets has the same properties as the previous batch.

The routine examination of animals in the Central Experimental Farm herd to detect infection with chronic-contagious mastitis has been continued. The incidence of infection has been reduced to the lowest level so far recorded. Penicillin therapy, combined with elimination of infected animals, has been given the credit for this improvement. Routine bacteriological control of the operations of the C.E.F. dairy has also been continued.

Butter.—The collection of data for commercial churnings on the relation between the initial acidity of cream, the acidity after neutralization, and the pH of butter serum was discontinued during the year and the data analysed. Three of the four co-operating creameries made from 75 to 82·5 per cent of the churnings within the recommended range of pH 6·7 to 7·2 by controlling the titratable acidity of the cream at churning. To maintain a uniform pH value of approximately 6·8 in the butter, the data indicated that it is necessary to adjust the desired acidity at the churn according to the initial acidity of the cream. Creams with an initial acidity of 0·25 or 0·3 per cent should be reduced to 0·11 or 0·12 per cent, while creams of 0·4 to 0·5 per cent acidity should be reduced to 0·13 to 0·14 per cent. In general, the desired acidity at the churn should be increased by 0·01 per cent for each increase of 0·1 per cent in the initial acidity.

The relationship between the initial acidity, the acidity after neutralization, and the pH of butter varies with the methods and conditions of pasteurization when soda-type neutralizers are used. With vat pasteurization, the titratable acidity at the churn is from 0·03 to 0·09 per cent higher than the desired acidity depending on the initial acidity of the cream, the desired acidity at the churn and the fullness of the vat. This is due to the evolution and retention of carbon dioxide gas in the cream during neutralization. The increased titratable acidity at the churn due to the retention of carbon dioxide, however, has little effect, if any, on the final pH of the butter. The main factors in the neutralization of cream to assure uniform pH values in the butter serum are an exact knowledge of the weight of cream in the vat, accurate initial acidity tests, an accurate calculation of the amount of neutralizer to use, and careful weighing of the neutralizer on accurate scales.

During the late summer, samples of print butter showing a "musty" or "slight musty" flavour were submitted to the Division for examination to determine the cause of the defect. The defect developed after removal from cold storage and after cutting into prints and distribution to the retail trade.

On examination, the butter showed normal pH values but very high total bacteria counts ranging from 2,000,000 to 4,000,000 colonies per ml. Stained smears of the butter serum indicated high numbers of gram-negative organisms. By the bottle test, samples of the butter developed decided "off" flavours at room temperture after 24 hours, which in one or two cases resembled "surface taint". *Pseudomonas putrefaciens,* the causal organism of "surface taint", was later isolated from the butter, as well as other gram-negative bacteria which produced a greenish pigment and completely digested skim-milk. Fruity and other off-flavours developed rapidly in skim-milk cultures at 70° to 72°F and at 40°F. The "musty" flavour of this butter was undoubtedly of bacterial origin and was probably due to species of *Pseudomonas.* Reports from the creamery where the butter was made suggest that the water supply was the original source of the organisms.

An outbreak of discoloration in so-called unsalted butter due to *Pseudomonas nigrifaciens,* the pigment-producing organism, was of interest. On examination, the butter was found to contain 0·65 per cent salt and contained large numbers of the causal organisms. The water supply was suspected as the source of contamination, but attempts to isolate the causal organism by direct bacteriological techniques and by washing butter granules with water from the two separate supplies used in the creamery were unsuccessful.

Continuous methods of buttermaking have continued to be of interest. An opportunity was afforded to an officer of the Division to observe and study the Cherry-Burrell process in operation. At the time of the visit, the process was still in the final stages of experimentation, but butter of good body, texture, and uniform composition was being manufactured. The process involves separation of ordinary cream to a fat content of 85 to 95 per cent, vacuum pasteurization of the high-fat product, standardization of the liquid high-fat mixture with the required amounts of moisture and salt to give uniform composition, and the final chilling and working of the liquid mixture to produce the desired consistency and body in the finished butter. It is expected that several large commercial creameries in the United States will be equipped during 1947 to manufacture butter by this process. Butter made by this process can be standardized to any desired composition to meet existing legal standards, and has a body and texture that will meet the requirements of butter markets on this continent.

Through the De Laval Company, Peterborough, Ontario, an opportunity was provided to examine a sample of butter made in Sweden by the Alfa-Laval continuous process. The general principles in this process are similar to those of the Cherry-Burrell process, but the equipment is somewhat different. The butter examined had a clean flavour, and the composition was well within Canadian legal requirements. The body of this butter was good but the texture at temperatures below 50°F. was slightly brittle or crumbly.

Cheese.—During the year a new method was developed for determining setting time in cheddar cheesemaking. The test depends upon the reduction of resazurin to its pink end-point and is called the "Pink Test". One ml. of A.P.H.A. standard resazurin solution is pipetted into a test tube to which 10 ml. of milk from a well-stirred vat is added. The tube is held at 86°F. and examined at the end of 5 minutes or until the original colour is reduced to pink. The vat is ready to set when this colour change takes place in 5 minutes. Cheesemaking experiments using starter at different levels were carried out to test the performance of the pink test. A single value can be adopted for the

pink test which is applicable under widely varying conditions, whereas setting-acidity varies from factory to factory and from season to season and must be determined by trial and error. The new test has been demonstrated to cheese-makers' groups and will be introduced to the industry during the coming year.

Previous studies have revealed that milk lipase can bring about rancid and unclean flavour defects in cheddar cheese. As both the extent and cause of the action of milk lipase may be influenced under certain conditions, the effect of acidity on the development of lipolytic flavour defects was studied. Attempts to inhibit the action of milk lipase by the addition of hydrochloric acid to milk, a portion of which was homogenized, or by making acidity cheese, were only partly successful. Results in another set of comparative experimental vats where the cheese milk was partially homogenized, in one vat immediately upon the addition of starter and in the other just before setting, showed that cheese made according to the first procedure scored higher for flavour by about one point. In further experiments, cheese milk in one vat was inoculated with a small amount of starter at night and held at 60° F. while the same milk in a second vat received 3 per cent starter in the morning. Milk lipase activity was induced in both vats by homogenization, resulting in the cheese from the first vat scoring more than one point higher in flavour. The results are explained on the basis of lipase inhibition by contact with acid over a period of time, as well as by the influence of acid or a set of conditions on the course of lipase action, so as to produce mainly non-volatile acids. Lipase in homogenized milk appeared to be more susceptible to the influence of acidity than in normal milk.

In conjunction with studies on milk lipase and lipolytic flavour defects, a simple method of determining the acid degree of cheese fat was developed. An average value of fat acidity on a series of 38 samples of experimental Canadian first grade cheese, covering a period of one year, has been established at 1·0 ml. N/10 NaOH per 10 grams for cheese 2 to 4 weeks old. Fat acidities on a series of commercial cheddar cheese, selected so as to include a high proportion of cheese degraded for unclean and rancid flavour, ranged from 1·2 to 4·6. The incidence of undergrade cheese increased as the acid degree increased. All cheese with an acid degree of 2·8 or higher were found to be below first grade on flavour.

Investigations carried on co-operatively with a commercial cheese firm on the cause of discoloration in malted process cheese were brought to a satisfactory conclusion. Recommendations put into effect by the manufacturer have eliminated a defect which was objectionable from the standpoint of merchandizing a quality product.

At the request of a manufacturer of process cheese wrappers, bacteriological checks were made during the year to determine sources of contamination. Results showed that while the main source of contamination was from the quality of the starch used in treating the wrappers, considerable numbers of organisms were picked up from the cutting, printing and folding machines. Sanitizing methods recommended to the manufacturer have successfully overcome the difficulties encountered.

A new technique was devised for determining sediment in cheese factory patrons' milk supplies. The test is based on the use of composite rather than on individual samples of milk. The advantages of the new method include a saving in the time required for sediment testing and a more accurate picture of the average conditions of each patron's milk supply as compared with the occasional sediment test now performed.

Concentrated Milks.—The Division continued the analysis of milk powders purchased by the Dairy Products Board for overseas shipment. During the fiscal year 3,654 samples were analysed for sediment, acidity, colour, flavour

and bacteria counts, used as a basis for grading. There was an increase of about 5 per cent in the quantity of powder in first grade as compared with 1945, with a corresponding decrease in the powder below second grade. The main defects again were due to high sediment and low acid values, although many samples were higher than the specified standards for fat. About 99·6 per cent of the samples were higher than the specified standards for fat, and had bacteria counts well within the standard for first grade.

Studies were undertaken to determine the effect of variations in the technique of bacteriological analysis on the total bacteria counts of milk powders. Preliminary examinations of the data indicate that for spray whole milk powder the use of 0·1N lithium hydroxide as the first diluent reduced the total plate count by approximately 75 per cent. The temperature of the diluent at the time of reconstituting the milk powder also affected the total plate counts, as did the temperature at which plates were incubated. The data indicated that to obtain the highest estimate of the viable bacteria in whole milk powder, reconstitution should be made in sterile water blanks at a temperature of approximately 50° C., and the plates should be incubated at 32° C.

Food Microbiology

Dried Eggs for Export to Britain.—Advice on the maintenance of adequate sanitation in Canadian egg breaking and drying plants was again a responsibility of this Division. Routine bacteriological analyses of each carlot directed attention to any plant having difficulty in meeting the bacteriological specifications for dried egg, and help was given to correct the trouble. Resident inspectors maintained bacteriological control in breaking rooms, using the Burri slant method.

Since January 1, 1946, all Canadian drying plants have produced sugared dried egg, a product for the bakery trade containing 33 per cent sugar. To compensate for this, bacteria count limits were reduced by approximately one-third. No plant had difficulty in meeting the viable count limit of 350,000 per gram, over 80 per cent of the counts in 1946 being below 25,000 per gram.

Studies started in 1945 on incubation temperatures for viable counts were continued during 1946. Counts obtained after incubation at 37°C. for 48 hours averaged only 53·9 per cent of those obtained after incubation at 32°C. for 72 hours. Since the latter is recommended in the section dealing with Eggs and Egg Products in the 9th edition of Standard Methods for Dairy Products, and since the experimental error is much lower at 32°C. it was recommended, and the recommendation accepted, that it be substituted for 37°C. for the official analysis of dried egg in Canada.

Frozen Eggs for the Domestic Market.—Large quantities of eggs are prepared and frozen during the flush season for use by bakers and others throughout the year. To protect the buyer, official grade standards have been sought. As an over-all measure of quality, including the bacteriological aspect, the reducing sugar content has been suggested. To check on the adequacy of this method, studies were carried out with the co-operation of the Poultry Products Division, Marketing Service, and the Division of Chemistry, whereby 126 samples of frozen egg were analysed in the field for reducing sugars, then a portion of the same core shipped in the frozen state to Ottawa where bacteriological and chemical determinations were made. Results showed an almost complete absence of any correlation between reducing sugar content and viable count, while reducing sugar determinations in the field often showed wide variations from values determined by the Division of Chemistry. It was concluded, therefore, that the reducing sugar content could not be relied upon as a basis for official grading.

Frozen Pack Fruits and Vegetables.—Studies begun in 1940 on the effect of freezing, defrosting, holding, and refreezing on the microbial content of fruits and vegetables were resumed in 1946. The general conclusion is that once the microbial content has increased as a result of defrosting, these higher counts will persist after subsequent refreezing. Sugar syrup, however, has the effect of checking the growth of micro-organisms and in some cases of reducing the count.

With a view to establishing microbiological standards, analyses were conducted at the Ottawa and Summerland laboratories on 64 commercial samples of frozen fruits and vegetables. Of the 44 vegetable products analysed, 73 per cent had bacteria counts higher than would be considered normal. A more extensive survey is planned for next season.

Studies on the effect of different methods of freezing upon the microbial content of beans and strawberries indicated that the air blast method caused a more rapid reduction in count than did the static method, but when examined after one month differences were not significant.

The microbial content of beans was reduced by 72 per cent by washing, and by 99·9 per cent by a subsequent steam blanching for 2 minutes at 204° F. Roccal, a quaternary ammonium germicide, was found to be of limited value when used as a dip to reduce the microbial load on strawberries and raspberries.

Dehydrated Vegetables.—A comparison of counts obtained from vegetables dehydrated during 1945-1946 with those for the early years of the war illustrates the enormous improvement in quality from a microbiological standpoint. While in 1939-1940 only 50 per cent of samples showed bacteria counts below 50,000 per gram, this had risen to 97 per cent by 1945-46, while samples positive for coliform organisms in 1/20 gm. portions had fallen from 52·4 per cent to 6·3 per cent during the same period. This improvement is attributed to: (*a*) constant supervision by officials of the Dominion Department of Agriculture, (*b*) improved methods of processing, and (*c*) the introduction of bacteria count standards.

Canned Fruits and Vegetables.—The examination of canned tomato products, using the mould content as a criterion of quality, was continued during the year with the co-operation of the Fruit and Vegetable Division, Marketing Service. Results were similar to those for 1945, and again indicated the need for a more rigid inspection of the initial stock and more adequate trimming. Of 3,180 samples examined in laboratories at Ottawa, Toronto, and Summerland, approximately 11 per cent were above the limit for mould content.

The Mould Count School established by this Division at the Ontario Agricultural College in 1945 was carried on again in 1946 by the college authorities. A similar school was held for the first time at the Summerland, B.C., laboratory from June 10 to 14, in co-operation with the Fruit Products Laboratory at that Station. This proved very helpful to the industry in that province, and it is planned to make it an annual affair.

Plant studies conducted at an eastern Ontario cannery in September proved very helpful in demonstrating to the canners the relationship between the quality of the raw material and the mould count of the finished product. Proper selection and trimming of tomatoes resulted in an appreciable reduction in mould content.

A number of spoilage problems were studied during the year, the more important of which involved solid pack apples, dill pickles and pureed vegetable soups. In each case the organism responsible was isolated and studied, and recommendations made for the prevention of future spoilage. Faulty processing and improper subsequent cooling of cans were mainly responsible for the trouble.

Canning Sugars.—Last year's survey showed that of 53 samples collected from canneries throughout Canada, 47 per cent failed to meet the standards

established by the National Canners Association. During 1946, 124 additional samples were submitted by inspectors of the Fruit and Vegetable Division, Marketing Service. Of these, 40 per cent exceeded the limit for flat-sour bacteria, 15 per cent exceeded the limit for non-sulphide-producing anaerobes, and only 0·8 per cent exceeded the limit for sulphide-producing anaerobes. Samples from certain refineries were consistently poorer in quality than those from others. During the year progress was made in the development of a simple test, suitable for plant use, for the detection of flat-sour bacteria in sugars.

Effect of X-rays on Yeasts.—Using a small commercial model of an X-ray machine, tests were conducted on apple juice inoculated with a mixture of three species of yeast. With a 5 mm. layer of juice there was a fairly steady reduction in count, but since over 20 per cent survived 10 minutes exposure, the method had little value for the sterilization of apple juice.

Ozone as Germicide in Fruit and Vegetable Storage Rooms.—Following preliminary tests in 1945, which showed ozone to be ineffective at 65° F., more extensive tests were run at 35° and 45° F. using 0·2 p.p.m. of ozone as recommended by the manufacturer of the generator. These showed that ozone had considerable effect in reducing the number of organisms, this being most marked at the lower temperature.

Edible Gelatine.—In co-operation with the Health of Animals Division, the bacteriological control of edible gelatine was continued. The quality of the product was well maintained, 98·4 per cent of all samples tested being within the bacteriological standards established for total numbers and coliform bacteria, as compared with 97·5 per cent for the previous year.

Soil Microbiology

Soil Micro-organisms in Relation to Manganese Deficiency in Oats.—Further study on manganese deficiency disease of oats showed that a variety of oats susceptible to this disease harboured in its rhizosphere greater numbers of manganese-oxidizing, casein-hydrolyzing, and denitrifying bacteria than did a resistant variety under identical conditions. The application of soil fumigants such as chloropicrin, cyanogas, or formaldehyde to diseased soil resulted in greatly reducing the numbers of, or completely suppressing, bacteria capable of oxidizing manganese. Furthermore, plants grown in soil so treated were free from symptoms of manganese deficiency and gave marked increased yields of grain. Application of straw mulch, on the other hand, resulted in larger numbers of manganese-oxidizing, and also of cellulose-decomposing organisms.

Statistical analysis of the data showed a significant positive correlation between the severity of the disease and manganese-oxidizing bacteria and cellulose decomposers; differences in yields of grain due to treatment were also significant. It was of interest to note that application of commercial calcium cyanamide at the rate of 190 lb. per acre resulted in practical control of the disease.

In studying the rhizosphere organisms, several were isolated which were antagonistic in various degrees towards other representative bacteria from the same rhizosphere and also towards fungi associated with root-rot conditions such as *Fusarium culmorum* and *Helminthosporium sativum*. It was of special interest to note that the most active antagonists were unable to exert any inhibition against four species of *Azotobacter* and two species of *Rhizobium*, all nitrogen-fixing organisms.

Soil Inoculants and Stimulants.—In addition to tests on commercial legume inoculants, further co-operative tests were made with the preparation "Bact-

Vita", claimed to be a stimulant for soil bacteria with resultant benefit to crop growth. Under the test conditions no stimulation was observed on numbers of bacteria, actinomycetes, or fungi in treated soil.

Though the practical value of soil or seed inoculants, other than legume cultures, is viewed with general scepticism, more recent claims made in Europe that treatment with cultures of *Azotobacter* has resulted in increased crop yields have suggested the value of re-examining the possibilities of this procedure for Canadian conditions. During the year experimental work was started with special emphasis placed on the possible importance of selecting strains of *Azotobacter* which might be specially adapted to specific crops. Work is being continued.

Development of Bacteria in Peat.—The suitability of peat as a medium for bacterial growth and viability is of importance from many aspects—from the standpoint of land utilization to that of the use of peat as a carrier for bacteria for purposes of soil inoculation. Extensive experiments have been conducted to note various factors affecting the growth and survival of bacteria in powdered well-humified peat and related products, including different lignites and charcoal, as well as in spongy, unhumified peat.

Well humified peat was found superior to other materials tested for maintaining the test bacteria in viable condition. Sterilization improved its qualities, and neutralization for which purpose potassium carbonate was found best, was of great importance. Though peat allowed to dry rapidly did not permit the same bacterial development observed in peat kept at suitable moisture content, it was able to maintain large numbers of organisms in viable condition. After suitable development of bacteria, peat maintained numbers better at low temperatures (4° C.) than at higher temperatures.

Peat from unhumified, surface deposits was likewise found well suited to the growth of the test bacteria and their maintenance in viable condition. Sterilization increased the buffering capacity of the peat. Neutralization, though important for peat which was heat sterilized, was much less essential with unsterilized peat. Under conditions of rapid desiccation, this type of peat permitted a more pronounced development of bacteria than the humified product, with numbers maintained at high levels.

The "Rhizosphere Effect" in Relation to Bacterial Nutrition.—Further fundamental studies on the physiology of soil bacteria have provided support for the belief that one of the most characteristic effects of plant growth is the preferential stimulation of organisms requiring amino acids. The findings suggest a relationship of this phenomenon to plant excretions, of which little is understood. Excretion of amino acids has been demonstrated in the case of legumes, and their excretion by non-legumes in amounts sufficient to modify the bacterial equilibrium in soil adjacent to the growing plant may be postulated. The evidence furnished by the studies is as yet indirect, as far as indicating the mechanism by which the development of special groups of soil bacteria in the rhizosphere is induced. However, the study of nutritive differences of micro-organisms in the rhizosphere is offered as a useful means of approach in obtaining a better knowledge of the physiological activity of the root system. Special attention is being given to differences in the "rhizosphere effect" of various crops, and to associative and antagonistic influences of micro-organisms which are factors in the establishment of equilibrium in soil.

Miscellaneous Investigations

Foulbrood Diseases of Bees.—A rapid, simple field test for American foulbrood, based on coagulation of milk, was developed. It consists essentially of macerating suspected material with 2 drops of milk on a piece of glass and

noting the time required for a firm curd to develop. Although European foulbrood scale was also found to coagulate milk, the time required was considerably longer than for American foulbrood, which with 90 per cent of the samples required less than 40 seconds, and with 70 per cent less than 30. Formaldehyde gas destroyed the enzyme system and rendered the test useless. Digestion of milk by scale was most rapid with fresh material at body temperature. Rapid digestion and coagulation of milk occurred only with scale or ropy material and not with healthy larvae or those in the early stages of the disease.

In view of the present interest taken in the possibility of employing antibiotics and sulphonamides for the control of foulbrood diseases of bees, tests were made of the antibacterial action of a variety of substances against strains of *Bacillus larvae, Bacillus alvei* and *Bacillus para-alvei.*

The materials used were sulphanilamide, sulphapyridine, sulphathiazole, clavacin, citrinin, penicillin, notatin, aspergillic acid, gliotoxin, streptomycin, streptothricin and tyrothricin. The sulpha drugs were much less effective than the antibiotics, the first two being active at a dilution of less than 1-1000. Sulphathiazole completely inhibited growth at a dilution of 1-1000 and certain strains at 1-5000. Of the antibiotics, penicillin and notatin were the most effective, supressing growth at dilutions of 5 and 10 million, and citrinin and aspergillic acid least, being active at dilutions of 1-20,000 to 80,000. Considerable variation among the strains tested was noted. Of particular interest was the differential effect of certain antibiotics on *B. larvae* and *B. alvei* and *para-alvei* strains. Gliotoxin completely inhibited *B. larvae* at a dilution of 1-80,000 but was active on the other species at 1-320,000 to 640,000. On the other hand, streptothricin completely suppressed *B. larvae* at 1-80,000 to 160,000, but the other species only at 1-1000.

In a study of the growth requirements of *B. para-alvei* it was observed that the organism grew abundantly in a synthetic medium of 15 amino acids in the presence of thiamin, and moderately in its absence. When phenylalamine, valine, isoleucine and cystine were all omitted from the medium, growth was not affected provided thiamin was present. In its absence, however, growth was negligible when all or any of these amino acids were omitted. Thus in the absence of thiamin these amino acids become essential for the organism. Since maximum growth occurs only with thiamin, it is likely an essential metabolite, and the results suggest that the four amino acids may be involved in the synthesis of the vitamin. Further confirmation of this hypothesis is being sought by use of thiazoleless and thiaminless mutant strains of *Neurospora* for assay purposes.

Butylene Glycol Fermentation.—Potassium, either as KCl or K_2HPO_4, was found to stimulate production of 2,3-butanediol from starch by *Bacillus polymyxa* and to increase the diol:ethanol ratio. In a casein hydrolysate medium, potassium alone produced this effect, however, in a synthetic (amino acid) medium, phosphorus was found to cause a slight increase in yield of diol especially in the presence of potassium.

Potassium, phosphorus and magnesium were shown to be required for growth of *B. polymyxa* in a synthetic medium containing glucose, amino acids and biotin. By means of "resting cells" of *B. polymyxa,* acting on glucose, it was demonstrated that potassium specifically stimulated the diol-synthesizing mechanism and that sodium could replace this element partially.

Antibiotics.—During the year studies on the isolation of actinomycetes having antibiotic properties against both gram-positive and gram-negative bacteria were followed by investigation of cultural conditions necessary for increased production of active substance, and with four cultures, attempts at concentration and purification.

Following several trials, a procedure for the rapid isolation of antibiotic actinomycetes from soil was developed, and proved useful in selecting 42 cultures for further study. Results of cultural studies indicated the need for a diversity of media and variation in physical conditions for the accumulation of antibiotic substances. Out of 42 original isolates active on agar only 24 were active on any of five selected media; and of these only 8 gave indication of worth-while production by further test.

Attempts to concentrate the antibiotic substances produced by four selected actinomycetes has resulted in obtaining crude extracts from two different cultures. These extracts exhibit antibacterial spectra different from each other and from those of streptomycin, streptothricin, and actinomycin.

Surface Active Compounds as Sanitizing Agents.—A new class of sterilizing compound, known as quaternary ammonium compounds, has recently been offered to the dairy and food processing industries to replace hypochlorites for the sanitizing of surfaces of equipment. It is claimed that these compounds have definite advantages over the hypochlorites. To check on these claims, an extensive investigation was undertaken, using the "glass slide" technique developed in these laboratories. Results to date indicate that the quaternary ammonium compounds were generally more effective than hypochlorites against gram-positive organisms; against gram-negative organisms, on the other hand, the hypochlorites proved definitely superior. Cheese starter organisms were an exception, being killed faster by hypochlorites. Three of the four quaternary compounds tested were comparable in efficiency, while the fourth was definitely slower. The hypochlorites responded much more readily to favourable adjustments in pH and temperature than did the quaternary compounds. Hard water supplies lowered the efficiency of the latter, but increased that of the hypochlorites. The quaternary compounds proved to be exceptionally stable in the presence of added skim-milk, while both types of compounds retained their germicidal potency in the presence of concentrations of skim-milk far in excess of those likely to be encountered in plant practice.

The possibility that unscrupulous persons might attempt to use quaternary compounds as preservatives in milk was investigated. While each of the four products tested exerted a slight but definite bacteriostatic action, their value for this purpose was extremely limited.

Services

During the year, 200 cultures for inoculating legume seed were prepared for Dominion Experimental Farms and Illustration Stations. Cheese starters were distributed to various cheese factories.

The general analytical service was continued during the year, chiefly in co-operation with other divisions of the Department. The work entailed the examination of 8,432 samples submitted for analysis. These included milk and manufactured dairy products, fruit and vegetable products, egg powder, gelatine and meat products, honey, foulbrood specimens, legume inoculants and feeding stuffs for riboflavin assay. The work was done largely in connection with the control of products within the scope of Acts and Regulations administered by the Department.

During the year 22 technical journal articles were submitted for publication as contributions from the Division.

DIVISION OF BOTANY AND PLANT PATHOLOGY

Botany Section

Systematic Botany.—During 1946, it was possible, for the first time in several years, to give more adequate attention to both routine and research work in the field of systematic botany. A large proportion of the unidentified material that had accumulated during the war years was determined and inserted in the Herbarium. The total number of specimens identified during the year was approximately 7,000. Field work was carried on chiefly in Western Canada and in the Ottawa district. A reconnaissance survey with a view to the ultimate preparation of a flora of the Canadian Great Plains was made during July and August. This survey also yielded extremely valuable material for the taxonomic studies of *Agropyron* and *Potentilla,* which are still in progress. Some 1946 specimens, including many duplicates, were collected. Exchanges with other institutions were increased during the year, 3,952 specimens being distributed and 2,719 specimens received. A total of 7,160 sheets was added to the herbarium, this being an increase of 1,413 over 1945. The herbarium now contains approximately 73,050 specimens. Part VII of the Bibliography of Canadian Plant Geography comprising additional references for the period 1635-1935 and author, geographic, and subject indices for all the previous parts, was published during the year. Work was completed on Part VIII, which covers the period 1936-1940, and work initiated on Part IX, 1941-1945.

Phenological Observations in 1946.—Again, as in 1945, spring opened abnormally early, with silver maple shedding pollen on March 21, about 24 days ahead of the previous 10-year average. Almost immediately, however, the dates for other species used for observation became progressively more seasonable until by May 1 they were about average and by June, and continuing into July, later than average. This is apparent from the following table.

Species	Ten-year Average	1944	1945	1946
Silver maple	April 14	April 17	March 25	March 21
American elm	April 27	April 30	April 3	April 7
Sugar maple	May 8	May 6	April 14	May 8
Scotch pine	May 27	May 24	May 27	June 1
Bitternut hickory	.....	May 30	June 14	June 16
American basswood	.....	June 29	July 6	July 10
Japanese knotweed	.....	Sept. 5	Aug. 30	Sept. 4
Witch hazel	.....	Oct. 5	Sept. 29	Sept. 19

Herbicide Registration.—Applications have increased to 56, of which 52 were for the various compounds of 2, 4-D. Factors reviewed include ingredients, guarantee, purpose of the product, direction for use, and text of label. The place of 2, 4-D in weed control is now understood more fully and this is reflected in a tendency toward greater uniformity in the labelling.

Ragweeds in Relation to Hay Fever.—Persons suffering from hay fever, in both Canada and the United States, are keenly interested in information concerning vacation areas that are free from ragweed. As the tourist trade is so valuable to Canada, it is most important that ragweed should not be permitted to spread into northern and eastern resort areas, now free from the weed. Certain regions, such as Prince Edward Island and the Lake St. John district, Quebec, are apparently now taking steps to eliminate completely the relatively

small amount of ragweed that surveys have shown to be present. In cities, where eradication by older methods has not been practicable, the use of 2, 4-D sprays may materially reduce the ragweed population.

Weed Incidence in Canada.—Work is being continued on the tabulation of field data obtained through the Dominion Weed Survey, during the past 25 years. Detailed percentage frequency data for some 325 species of weeds are now available; these data have been derived from a large number of individual surveys of weed occurrence. The data provide valuable information on the distribution of the most important weeds of the agricultural areas of Canada. Less complete information is available on the occurrence of several hundred other weed species. The results of the Dominion Weed Survey have formed the basis for a series of four annual reports on weed distribution in Canada.

During 1946, weed surveys were carried out in the Lake St. John district of Quebec and along the northwest frontier from the Carrot River district in Saskatchewan to Fort Vermilion in northern Alberta and Fort St. John in British Columbia. In this northwest frontier area native species still predominate and the introduced species are largely free-seeding annuals, such as shepherd's purse, wild buckwheat, stinkweed, and ball mustard. Introduced perennial weeds which are present occur largely as isolated infestations. For example, at Keg River, Alta., an infestation of perennial sow thistle was found occupying only a few square rods of a field; at Fort Vermilion, Alta., there was a roadside infestation of leafy spurge. Both at Fort Vermilion and Carcajou, Alta., thyme-leaved dragonhead was found. This is one of the newer weeds, now known to be present across much of Canada. There was a surprising abundance, in the northwest frontier area, of such introductions as Russian pigweed and flixweed. The density of these infestations has scarcely been equalled in any more southern or eastern region and indicates that these weeds are perfectly adapted to the northwest area. All such observations emphasize the necessity of a continuously active weed survey.

Weed Control.—Applications of kerosene and 2, 4-D (2, 4-dichlorophenoxyacetic acid) were made to common dandelion growing in a Kentucky blue grass lawn in the Dominion Arboretum and Botanic Garden, Ottawa, on August 31, 1945. From observations made in May of the following year, it was evident that kerosene gave good control of common dandelion but 2, 4-D little or no control. The results with the acid were contrary to what was expected on the basis of reports in the literature dealing with this material.

Several visits were made to weed control experiments conducted by the Ontario Department of Agriculture and the Quebec Department of Agriculture to assist in the identification of the weeds present and to advise as to the effectiveness of the various herbicides applied.

Studies in Seed Germination Behaviour.—For a number of years 104 species of weed seeds have been subjected to a standard laboratory germination test. During the first year after being collected, each sample of seeds was tested at monthly intervals. Each subsequent year the samples have been retested to observe any changes in germination capacity.

A compilation of results from the germination tests with seeds which had been stored for ten years showed several interesting observations. The lowest average germination, namely 0·77 per cent, occurred in the family Compositae (Daisy family), in marked contrast to the family Gramineae (Grass family) which had the highest average germination with 60 per cent. A possible explanation for this difference in germination capacity is that the species representing the Compositae family were practically all perennials, whereas the species of Gramineae tested were largely annuals.

When ten-year old seeds were tested in the greenhouse, 70 per cent gave results comparable with the laboratory germination tests. Twenty-two of the seed samples did not germinate in either laboratory or greenhouse and were assumed to be dead.

Dodder Investigations.—In conjunction with provincial officials, visits were made to farms in Ontario and Quebec where dodder is a problem. The recommendations given have been helpful in preventing the further spread of this noxious weed.

At the co-operative dodder control plots near Alexandria, Ont., several important facts were demonstrated. The dodder did not grow on the cereals, annual crops for hay, or soybeans, which have been the crops recommended for use on dodder-infested land. Dodder flowered and produced capsules on buckwheat, flax, peas and clovers. The contention that a heavy stand of buckwheat will prevent dodder from developing normally was refuted. Dodder capsules were found on all the buckwheat plots, even on those which had been sown at double the normal rate.

The herbicide 2, 4-D gave fairly satisfactory control of the hosts susceptible to dodder, such as flax, buckwheat, Canada thistle, curled dock and common mustard, only if applied when the plants were small. Less satisfactory results were obtained when 2, 4-D was applied to plants more than one foot in height since a sufficient number of them survived to enable the dodder to develop capsules. Of the four types tested, the free acid type of 2, 4-D formulation gave the best results.

Poison Ivy Eradication and Extension Service.—Considerably more experimental work on the use of herbicides in the eradication of poison ivy was conducted this year, and observations were made on the effectiveness of sprays applied by the Montreal Department of Health and the Quebec and Ontario Departments of Agriculture. In all these experiments, it was increasingly evident that 2, 4-D does kill the top growth at least, and perhaps the roots as well. Less than 10 per cent regrowth was observed as compared with 20 per cent in the areas sprayed with sodium chlorate in the form of Stephen's Weed Killer.

In the Ottawa district a series of tests was conducted to compare the effectiveness of the four types of 2, 4-D formulations, at concentrations ranging from 1000 to 2000 p.p.m. This experiment followed the plan outlined by the research section of the North Central States Weed Control Conference. In general, the ester type of 2, 4-D gave more satisfactory results than the three other types.

In 1945, single applications of 2, 4-D gave a slightly better control of poison ivy than did ammonium sulfamate, and both these materials were definitely superior to sodium chlorate. From applications of ammonium sulfamate and 2, 4-D made during the months of June, July, August, and September, 1945, the best control with both these materials was obtained from the June treatments. The July, August, and September applications did not give satisfactory control, although those of ammonium sulfamate resulted in a greater reduction of poison ivy than did the respective ones of 2, 4-D.

Follow-up visits were made to several army camps to evaluate the effectiveness of control measures taken there against poison ivy and to advise on further work to be undertaken. Numerous requests for information on all phases of the poison ivy problem continue to be received.

Cytogenetics of Taraxacum Kok-Saghyz (Russian Dandelion.)—During 1946, cytogenetic studies of *Taraxacum kok-saghyz* were continued as part of a long-term program with the aim of producing a uniform strain of kok-saghyz with high rubber content and high vigour. Some 4,800 seedlings were grown

from seed produced in the crossing program of 1945. The plants were analysed for rubber content by the Koialovich method and data taken on green root weight. Only two of the new crosses appeared to be especially promising and one of these was a cross with 93·24 as one of the parents. This line has been the most satisfactory parent yet selected. A large number of new crosses were made in the greenhouse to provide seed for 1947. It has been found that a certain number of lines tend to be incompatible and that this incompatibility is not lessened in tetraploid material. Considerable difficulties were experienced in growing the kok-saghyz material, owing to flooding in the field and root aphids in the greenhouse. Satisfactory means of controlling the aphids have not been found. A number of hybrid seedlings (*T. kok-saghyz* × *T. latilobum*) flowered freely and a study of the hybrid and its progeny is being continued.

Cytotaxonomy of Agropyron.—Several years ago a purely taxonomic study of the Canadian species of *Agropyron* was initiated. This genus is very complex taxonomically and includes a number of important species, such as *A. repens*—one of the most wide-spread and serious Canadian weeds—and *A. spicatum, A. Smithii* and *A. trachycaulum,* which are important range or forage grasses.

It is apparent that cytological and genetic studies should aid considerably in gaining an understanding of the various sub-genetic units. Besides, these studies might yield material of much potential value to plant breeders working with cereals or forage plants. During 1946, a large number of carefully selected plants were collected, especially in Manitoba, Saskatchewan, and Alberta. The collection included herbarium specimens as well as living plants for cytological examination and genetical studies. Collaborators across the Dominion assisted with the collection of this material. Almost, but not quite, all the forms known to occur in Canada are now represented in the living plant collection. A limited number of European species have been grown for comparison. Somatic chromosome counts have been made on 83 plants. Diploid and tetraploid races have been found in *A. spicatum,* and tetraploid and octoploid races in *A. Smithii.* All the plants of *A. dasystachyum* and *A. trachycaulum* thus far examined are tetraploid and those of *A. repens* hexaploid. Preliminary results indicate that both *A. trachycaulum* and a new undescribed species from the Yukon are self-fertile. The work is being continued.

Physiological Experiments with Rubber-Bearing Plants.—The 1945 crop of kok-saghyz and milkweeds was analysed for resin and rubber content during 1946. The study of seasonal variation in rubber content of kok-saghyz, milkweed, and dogbane was continued. In kok-saghyz, it was found that during the first year of growth both dry weight and rubber content increased rapidly until September, when further increase in both tended to diminish. In the spring of the second year of growth, the dry weight decreased slightly but the rubber content increased somewhat. During the remainder of the second year, the dry weight again increased somewhat and the rubber content continued to increase throughout the growing season.

Propagational vigour in kok-saghyz increased slightly during the first year of growth, but in the second year it decreased almost to zero in the spring, increased rapidly to a peak in mid-summer, and then fell off somewhat in the fall.

From the analytical results for clonal kok-saghyz plants grown in different years, it has been found that a moderate amount of variation occurs between individuals within clones in any given year as well as in different years. In general, however, there was good comparative agreement between clones, as those clones that had a high rubber content in any one year had also a higher than average rubber content in other years. Likewise those with a low rubber content always tended to be low.

Kok-saghyz root cuttings, derived by vegetative propagation, were planted in the field as well as in flats in the greenhouse in May. Only seven per cent of the cuttings planted in the field survived while in the greenhouse the survival was fifty per cent.

Plant Physiology.—Progress has been made in developing the infra-red absorption method for the rapid determination of photosynthetic, respiration, and transpiration rates.

Dominion Arboretum and Botanic Garden.—The Arboretum was maintained in better condition during 1946 than it had been for many years. This was due in a large degree to the purchase of new mechanical equipment, including a light truck, tractor and gang mower. Additional equipment is still required, but this increased degree of mechanization has meant that labour could be used much more efficiently. It was possible to undertake, and at least partially complete, a considerable amount of new construction and planting. A large area in the southern part of the Arboretum was ploughed and prepared for reseeding. The swamp area in the southeast corner was cleared in preparation for new plantings. Approximately 750 established trees and shrubs were moved to new locations in order to make the arrangement conform with a systematic plan. Some 2,272 plants were moved from the old nursery to permanent locations or to the new nursery. Approximately 2,000 trees and shrubs were transplanted from the greenhouse to the nurseries. Two new beds were added to the iris garden. The number of gladiolus varieties was increased to 505, and 150 seedlings, including a test lot from the Gladiolus Growers' Council, grown for trial. Over 10,000 plants of 200 varieties of annuals were grown for display purposes.

Mapping of the whole Arboretum was completed and kept up to date. Approximately 200 specimens of trees and shrubs were identified and display labels were made for them. During the year 3,154 lots of seeds and plants were received by exchange and purchase from 86 botanic gardens and other institutions in Canada and 21 foreign countries. Requests for seed were received from 170 institutions, to which 3,314 packets of seed were distributed. A seed exchange list was again issued. Through the courtesy of the Experimental Farms Service, this list included seeds of commercial cultivated varieties of cereals, forage plants, garden vegetables and flax.

Plant Pathology Section

CENTRAL LABORATORY—OTTAWA, ONT.

Plant Disease Survey.—The Annual Report of the Canadian Plant Disease Survey for 1945 was prepared and published during the year.

Stem rust (*Puccinia graminis*) of wheat was virtually absent in fields of rust-resistant varieties in Manitoba, but the amounts of rust recorded on susceptible wheats grown experimentally indicated that heavy losses would have occurred had the farmers of Manitoba been still dependent on the old susceptible varieties. Leaf rust (*Puccinia triticina*) was severe in most parts of Canada. Moreover, wheats such as Regent and Renown that were previously resistant were almost as heavily rusted as was Thatcher, owing to the prevalence of races of leaf rust to which they are susceptible. Similarly, crown rust (*Puccinia coronata*) and stem rust of oats were severe in Manitoba and many parts of Eastern Canada due to the unprecedented prevalence of races to which the hitherto resistant varieties are susceptible. The severity of these rusts in localized areas in eastern Ontario focussed attention on the alternate hosts, the barberry and buckthorn, and the great improvement that could be brought about by their eradication.

Bacterial wilt (*Corynebacterium insidiosum*) of alfalfa has now spread in Alberta into the northern seed-producing areas; it was also reported for the

first time in Manitoba. Winter crown rot (low-temperature basidiomycete) was less destructive than usual in Alberta in 1945, but it was found in southern Saskatchewan. Crown wart (*Urophlyctis Alfalfae*), a new disease in Canada, was reported in British Columbia.

Most parasitic diseases of flax were generally light in Saskatchewan, but, on account of dry conditions, yields were below average and physiologic troubles were more conspicuous.

Bacterial ring rot (*Corynebacterium sepedonicum*) is still one of the most important diseases of potatoes and is receiving increasing attention. The remarkable success of the provincial officers in reducing the incidence of the disease in Alberta demonstrates that, even where the disease has become thoroughly established, it can be brought rather quickly under control, provided vigorous measures are taken to detect its occurrence and halt its further spread. Bacterial ring rot is limited to sporadic outbreaks in Nova Scotia, Prince Edward Island, and British Columbia. It appears to be spreading in Manitoba and Saskatchewan, but eradication measures are being vigorously prosecuted in Ontario. In Quebec and New Brunswick, where ring rot has been known the longest, the disease is evidently far from being under control.

The potato rot nematode (*Ditylenchus destructor*), a newcomer to Canada, was found at two points in Prince Edward Island. Vigorous steps have been taken to prevent its further establishment. Intensive search in 1946 failed to uncover additional infestations.

A few of the more important observations on other vegetable diseases may be mentioned. Charcoal rot (*Macrophomina Phaseoli*), reported on soybeans last year in southwestern Ontario, was found this year to be abundant on navy beans in fields on dry sandy soil in the same area. The bacterial blights of beans, particularly halo blight (*Pseudomonas medicaginis* var. *phaseolicola*), appear to be increasing in Canada. The freedom from disease of bean crops grown from seed produced in the Kamloops district of British Columbia, and in certain areas of California, has stimulated interest in the possibility of producing disease-free seed stocks in Canada under a system of certification. With absolutely disease-free seed and rigid isolation of the seed plot, it should be possible to grow disease-free seed in areas where the blights are destructive. Downy mildew (*Peronospora Schachtii*) of beet, a relatively new disease in North America and first observed in Canada in coastal areas of British Columbia in 1940, was observed in the Interior in 1945. Neck rot (*Botrytis Allii*) was more destructive than usual in stored onions due to the wet fall of 1944; storage conditions, however, were not always the best.

Attention may likewise be directed to a few of the fruit diseases. Apple scab (*Venturia inaequalis*) was unusually severe in Ontario and eastward; defoliation and loss of crop were common in poorly sprayed orchards. Brown rot (*Sclerotinia fructicola*) of peaches caused heavy losses in the Niagara Peninsula and cherry leaf spot (*Higginsia hiemalis*) was unusually severe in southern Ontario. The rapid spread of little cherry, a virus disease, in British Columbia has caused much concern. Downy mildew (*Plasmopara ribicola*) of gooseberries, not previously known in Canada, was found in Ontario. Decline (virus), first reported in Cuthbert raspberries, is now spreading to other varieties in British Columbia. Red stele (*Phytophthora Fragariae*) recently recognized for the first time in British Columbia, has been shown to be well established and to have caused heavy loss in the Fraser Valley.

New or unusual records of diseases on ornamental plants are also recorded.

Mycological Studies, including the Maintenance of the Mycological Herbarium.—Only about 100 specimens were collected in the Ottawa district in 1946, but of these 17 were new records for the district, the following 8 being apparently new to Canada: *Alternaria* sp. on *Papaver orientale*, *Cercospora*

Ceanothi on *Ceanothus ovatus, Cercospora Lysimachiae* on *Lysimachia terrestris, Cercosporella scirpina* on *Scirpus pedicellatus, Ovularia pulchella* var. *Agropyri* on *Agropyron repens, Physalospora hypericina* on *Hypericum perforatum, Ramularia rosea* on *Salix sp.*, and *Titaespora detospora* on *Equisetum littorale.*

A study was begun on the fungus flora of eastern Quebec centering about Ste. Anne de la Pocatière. First reports for North America were: a race of *Coleosporium Campanulae* attacking *Campanula rotundifolia, Puccinia Ptarmicae* on *Achillea Ptarmica.* First reports for Canada: *Cystopus Lepogoni* on *Spergularia canadensis, Phytomonas rathayi* on *Dactylis glomerata, Puccinia Campanulae* on *Campanula rotundifolia.* First reports for Quebec: *Physoderma Menyanthis* on *Menyanthes trifoliata, Puccinia calthaecola* on *Caltha palustris, Urophlyctis pulposa* on *Atriplex carnosa.* New host records for Quebec: *Puccinia Clematidis* on *Ranunculus Cymbalaria* and *Puccinellia pumila,* and *Pucciniastrum Pyrolae* on *Chimaphila umbellata* and *Pyrola minor.*

The past season was unfavourable for the development of fleshy fungi. However, 176 species were collected during a two-week period at St. Aubert, Que.

Determinations were also made on about 200 submitted specimens. Among these were eight first reports for Canada, four new provincial records, and two on hosts new to science for the fungi concerned. These last two were *Cercospora manitobana* on *Shepherdia argentea* in Manitoba and *Erysiphe Polygoni* on *Asarum canadense* in Quebec.

An illustrated monograph of the genus *Dermea* in North America was published in 1946. Sixteen species were described, of which fifteen have been studied in culture. Further work is proceeding with other genera of the group, especially with *Durandiella* and *Tympanis.*

The reference collection of pure cultures of the Sclerotiniaceae now contains 468 cultures, approximately 100 being salvaged from the collection of the late Professor Whetzel. The cultures of the Dermateaceae amount to 548, representing 135 species. The collection of seed-borne fungi, principally of the Fungi Imperfecti, contains 400 cultures of 250 species, with about 300 unidentified cultures.

An interesting collection of 54 cultures isolated from textiles in the southwest Pacific and other tropical areas was received for identification from the United States Army Quartermaster's Corps. Of these, 24 have been identified as species of *Alternaria, Stemphylium* and *Curvularia;* the remainder have yet to be determined.

A study of *Cercospora Lysimachiae* revealed that it is systemic within the host. A start was made on the taxonomy of the genera *Cercosporella, Ovularia* and *Ramularia.* The taxonomic status of these genera is at present in a chaotic state owing to inadequate descriptions and the variability in many species.

Exclusive of mushrooms and wood-rotting fungi, 1,814 specimens were added to the Herbarium; 528 were received in exchange from other institutions. Some other sources were: 329 smut fungi from Dr. Ivan H. Crowell, 150 seed-borne and soil fungi, 120 parasitic fungi collected locally, and 80 from eastern Quebec. In all, 1,417 specimens were sent out in exchange to other herbaria.

Intercepted Shipments of Imported Nursery Stock.—Samples were examined for disease from a total of 789 variety lots out of 471 shipments of nursery stock, nearly twice the total for the previous year. Shipments were principally from Holland and the United States. Tulips, narcissi, crocuses, gladioli, irises, and hyacinths, in descending order, constituted the bulk of the intercepted material, 52 different crops being represented. No new diseases were found, but several severely diseased shipments were discovered, including crocuses with 95 per cent Fusarium rot, irises with 60 per cent nematode infection, and several

lots of gladioli with high percentages of various diseases. Tulips, and to a lesser extent other bulbs and corms, showed abnormally severe mechanical injury, probably due in large part to inadequate packing.

Seed-Borne Diseases.—Laboratory studies to determine the prevalence and importance of seed-borne organisms were continued at the Central Laboratory, Ottawa. Representative samples of 952 seed stocks were critically examined for the presence of pathogens: 347 samples of peas, 126 of beans, 136 of flax, 6 of sugar beets, 5 of swedes, 5 of tobacco, 175 of vegetables, 123 of cereals, and 28 of clovers and grasses.

Individual health reports were issued on each sample examined. Based upon these laboratory tests, three types of recommendations were made in regard to the suitability of the seed for seeding purposes: (*a*) Suitable, (*b*) Suitable, if the seed is treated with a recommended fungicide, and (*c*) Unsuitable, owing to the presence of destructive seed-borne pathogens. When treatment was deemed advisable, specific treatments were recommended.

More than 200 species of fungi have been isolated, and determined as being seed-borne. A large collection of living cultures of these fungi is being maintained in order to carry on pathogenic tests as time permits. A fourth paper dealing with the identity of these fungi was published.

In the Ottawa district, 189 crops were inspected for disease, in accordance with a regulation passed by the Canadian Seed Growers' Association requiring that foundation, elite, and certain registered crops be inspected in the field by a plant pathologist.

Two separate trials were conducted to determine the comparative efficiency of two seed-treating machines, the Robinson and the Improved Kemp. Biological tests were made on samples of oats and barley taken at regular intervals during the treatment run. These tests involved the plating out of 100 seeds of each sample on prepared malt agar which had been flooded with spores of the indicator fungus, *Helminthosporium sativum*. The adequacy of dust coverage was determined by the extent of inhibition of fungus growth around the individual seeds. The results indicated that adequate treatment of the seed was obtained in both tests by both machines.

In co-operation with the Horticulture Division, bi-weekly inspections were made of Foundation seed stocks of beans grown in the greenhouse, with a view to providing a source of disease-free seed.

Some results obtained by the Division of Horticulture, Experimental Farms Service, in connection with the breeding of peas for resistance to *Ascochyta Pisi* indicated that more than one pathogenic strain of this organism may exist. An experiment to test this possibility was set up in the inoculation chambers in the greenhouses of that Division. Fifteen cultures of *A. Pisi*, isolated from pea seed produced in Ontario, Quebec, Saskatchewan, Alberta, and England, were selected. In addition, one isolate from seed of common vetch and one from seed of hairy vetch were included. A susceptible variety, Thomas Laxton, and a hybrid of V.C. × American Wonder, which had shown resistance in previous tests, were grown in flats and inoculated with a spore suspension of each isolate. Three weeks later, the plants in each flat were rated for disease reaction. The experimental results indicated the variety Thomas Laxton to be susceptible and the V.C. × American Wonder Cross hybrid to be resistant to 10 of the isolates, both to be susceptible to 3 other isolates, and both to be resistant to the remaining 4 isolates (including the two isolates from vetch). Thus there is evidence that *A. Pisi* comprises at least three different pathogenic races, or strains.

Several methods for testing the varietal susceptibility of peas to *Ascochyta* spp. have been investigated. Of these, the method showing most promise is to germinate surface-disinfected pea seed on sterilized filter paper in test tubes

containing a small amount of water. The best infection was obtained by inoculating the resulting seedlings about 8 days after the seed was placed in the test tubes.

Field experiments were carried out to investigate the relation between percentage of the seed infected with *A. Pisi* and disease development in the field. Three seed lots were used: (*a*) healthy seed, (*b*) moderately infected seed—4-6 per cent of the seed infected, and (*c*) heavily infected seed—over 20 per cent of the seed infected. The percentage emergence for the three seed lots was 78, 70, and 68, respectively, and the yield in bushels per acre was 50·1, 48·4, and 41·8, respectively. It would appear, therefore, that as the percentage of infected seed increases, the emergence and yield tend to decrease.

Seed treatment experiments were carried out in the field with samples of the moderately and the heavily infected seed lots. The samples were treated with Spergon, Ceresan, and Arasan. Due to heavy flooding of the land shortly after planting, emergence was uneven on some of the plots. However, the respective percentage of emergence in plots sown with moderately infected seed was 72, 82, 79, and 80 for the Check (untreated), and the Spergon, Ceresan, and Arasan treatments, and, in the plots sown with heavily infected seed, 75, 85, 83, and 70 per cent. In practically all cases, the emergence was higher for the treated than for the untreated seed, being the highest for Spergon-treated seed. The yield in bushels per acre from moderately infected seed was, respectively, 51·4, 45·2, 58·7 and 51·8 for the Check, and the Spergon, Ceresan, and Arasan treatments, and for the heavily infected seed, 39·6, 55·4, 55·6, and 62·4 bushels. These differences are not statistically significant.

A seed-drill survey of oats planted by farmers in eight counties in eastern Ontario in 1946 was carried out in co-operation with the Ontario Department of Agriculture. The prevalence of surface-borne smut was determined by the centrifuge test. All of the samples carried smut spores. The percentage of samples carrying a slight, moderate, and heavy spore load was 26, 11 and 5 per cent, respectively. Thus, 42 per cent of the oat samples required treatment for the control of surface-borne smut. In addition, as a result of seed examination for seedling root-rot and leaf-spotting organisms, only 20 per cent of the 84 samples were found suitable for seeding purposes without seed treatment. These findings indicate that most of the farmers in eastern Ontario should treat their seed oats annually with organic mercury compounds.

Bacterial Ring Rot of Potatoes.—Tubers from 79 lines of the Empire Potato Collection of which there was sufficient material for the purpose, were inoculated with the bacterial ring rot organism and planted in the field. The season was, however, unfavourable for the production of tubers, and only 7 lines became visibly infected with ring rot. Trials with the remaining lines in the collection will be continued next season in the greenhouse where conditions can be controlled and a crop of tubers assured.

The new potato variety, Teton, created by the United States Department of Agriculture and the Maine Agricultural Experiment Station, was tested for its resistance to bacterial ring rot. The tubers for this test were supplied by the Ontario Department of Agriculture. One lot of 100 sets was inoculated by placing a suspension of a pure culture over each eye and puncturing through the drop down at least to the vascular ring. A similar lot was inoculated by cutting the tubers into sets with a knife contaminated by first cutting through an infected tuber. Twenty-one of the 83 plants from the needle-inoculated sets (25 per cent), and 26 of the 92 plants from the knife-inoculated sets (28 per cent) showed the macroscopic symptoms of ring rot at harvest time. No ring rot was observed in the uninoculated checks. Smears from 18 tubers from affected plants were stained and examined microscopically. Only smears from six tubers revealed the presence of the ring rot organism. The other 12 tubers will be

planted and the plants kept under observation. It will be seen that the variety Teton is highly resistant, but not immune. Fear is entertained that it may prove a symptomless carrier of ring rot.

The overwintering of *Corynebacterium sepedonicum* on jute bags was again demonstrated. Ring rot infected tubers were placed in a bag when they were harvested in 1945. The bag was later emptied and kept over winter in the storage room. In the spring, 100 freshly cut sets were vigorously shaken in the bag and planted immediately. At harvest time, tubers from 12 per cent of the plants from these sets were found to be lightly infected with ring rot.

Other Potato Diseases.—In order to compare tuber-indexing with tuber-unit planting for the control of virus diseases in seed potatoes, 1,000 tubers produced by plants from tubers indexed in the greenhouse in 1945, were indexed in 1946 and then planted in the field by tuber-units. Another 1,000 tubers produced by plants from tubers planted by tuber-units in 1945, were planted by tuber-units in 1946. The 1,000 indexed tubers produced 911 apparently healthy plants, whereas the 1,000 planted by tuber-units produced only 701 such plants. For the three years that the experiment has been carried out, 1946 is the first in which there has been an appreciable difference between amounts of virus disease in the tuber-indexed and the tuber-unit planted stock. Owing to the very late spring in 1945 and the consequent delay in roguing, it is believed that aphids appeared and spread virus diseases from infected plants to the healthy in the tuber-unit planted plots before roguing, and that symptoms did not appear until 1946. On the other hand, there were no infected plants in the tuber-indexed plots from which aphids could spread disease, because any infected tubers had been removed during indexing in the greenhouse.

For three years, an attempt was made to determine whether virus-infected tubers could be separated from healthy ones by differences in specific gravity, namely, by floating out three quarters of the tubers in a magnesium sulphate solution. However, there was no significant difference in the number of virus-infected tubers among the "sinkers" and the "floaters".

A co-operative experiment was undertaken with the Division of Field Husbandry, Central Experimental Farm, to determine whether potato seed stocks can be maintained relatively free from virus diseases, in the Ottawa district, by tuber-unit planting and thorough roguing. These stocks remained fairly free of disease in 1944 and appeared healthy throughout 1945. However, when 200 tubers from each variety were tuber-indexed in the greenhouse in the winter of 1945-46, it was found that the Green Mountain and Irish Cobbler potatoes were 100 per cent virus infected and the Katahdin tubers 62 per cent.

This higher infection is believed to be due to slow growth and late roguing in 1945, which permitted spread of virus diseases by aphids. The experiment was begun again by planting Foundation certified seed in 1946.

In order to determine whether or not viruses are uniformly distributed in potato tubers, 100 Green Mountain and 100 Irish Cobbler tubers, known to be infected with virus diseases, were selected. The eyes from each tuber were removed serially beginning at the stem end, and planted in the same order. All eyes from both varieties produced virus infected plants, indicating that the virus was distributed throughout these tubers.

In a search for a suitable herbicide with which to kill potato tops and thus prevent tuber infection by spores of late blight from the vines, Dow G-502 (Dowspray 66 Improved) was found to give the most rapid kill, but Dow G-506, Sinox, and Handy Killer (sodium arsenite) also completely killed the plants within a reasonable time. The effects of 2, 4-D, either alone or with Sinox, were too slow for practical purposes. All the chemicals used caused a slightly

greater amount of vascular necrosis in the tubers than that which occurred in those from the check plot, the greatest amount being in the tubers from the plots treated with Sinox.

The breakdown of potato tubers in cold storage was studied in co-operation with the Division of Horticulture, by storing tubers at 32 degrees, 36 degrees and 39 degrees Fahrenheit. Two varieties were used, Katahdin, very subject to breakdown, and Green Mountain, not readily affected. They were examined every two weeks to determine approximately the time of onset of the trouble. Records were also kept of surface discoloration, flavour or the development of sweetness, and of soluble solids (sugars) as determined by refractometer readings of the extracted juice. Surface discoloration developed earliest and to the greatest extent in Katahdin tubers held at 32 degrees, and last and to the least extent in those kept at 39 degrees. No surface discoloration occurred on any of the Green Mountain tubers. Flavour tests indicated that tubers of both varieties stored at 32 degrees developed sweetness rapidly, those at 36 degrees more slowly, and those at 39 degrees not at all. In each case, the Green Mountain tubers tasted sweeter than the Katahdin tubers kept at the same temperature. The increase in sweetness was directly proportional to the amount of soluble solids as determined by refractometer readings of the juice expressed from the tubers. The readings were highest for tubers kept at 32 degrees, intermediate for those at 36 degrees, and the lowest for those at 39 degrees. They were generally higher for the Green Mountain tubers than for those of the Katahdin variety. These varied from 10·3 to 4·8 per cent. Low temperature breakdown appeared in Katahdin tubers after 59 days storage at 32 degrees. At the end of 129 days, it was severe in the Katahdin tubers at 32 degrees, but only a trace appeared in the Green Mountain tubers at the same temperature. No breakdown occurred in the tubers of the two varieties stored at 36 degrees and 39 degrees.

In an effort to determine the cause of necrosis in potato tubers, the effects of 16 different growing periods obtained by planting and by harvesting at 4 different dates, of frost injury to the potato tops, and of heavy ground frost, were again observed. There was no significant difference in the amount of necrosis between tubers from plots grown for different lengths of time, or from plots harvested after the first killing frost or after a heavy frost sufficient to form a crust on the surface of the ground.

Downy Mildew of Hop.—As downy mildew is a serious disease in the hop growing district around Fournier, Ont., the experiment to demonstrate the superiority of wet sprays and to select the best fungicide for the district, was continued by using bordeaux mixture, zinc sulphate-hydrated lime, Cuprocide 54-Y, and lime sulphur-resin mixture. A spreader-sticker was used with the first three sprays, and six applications were made, using a power sprayer and a spray gun directed by hand. Yields and quality of the crop were recorded. Downy mildew infections were observed on basal and lateral spikes and lower leaves at the beginning of the season in all the plots. These were stripped off about July 1. Only traces of mildew were seen from then on in the sprayed plots, except on one plant in a zinc sulphate sprayed plot which was not stripped of infected parts, and which became severely infected in spite of the spray. Infection was general in the check plots; the vines had fewer branches bearing fruit clusters, and a large number of the cones were infected. The bordeaux mixture sprayed plots gave the highest yields, the plots sprayed with the other three materials were intermediate, and the check plots were lowest.

Forest Pathology.—An examination of the Sudbury district for symptoms of injury caused by sulphur dioxide to trees and shrubs was made again this

year. These surveys are carried on in co-operation with the Ontario Department of Lands and Forests and of Mines. In contrast to 1945, the growing season of 1946 was extremely dry. It is well known that, under conditions of low relative humidity and low soil moisture content, plants become highly resistant to injury by sulphur dioxide. Further, it is probable that the amount of sulphur dioxide emitted to the atmosphere was substantially less in 1946 than in either of the two preceding years. In view of these two factors, therefore, it was not surprising that much less damage should be observed than in the two previous years. In fact, no injury was seen except at points comparatively close to Copper Cliff. Owing to the lack of adequate precipitation, white birch, where growing on thin soil, began to show yellowish discoloration of its foliage by the end of July and this condition rapidly intensified until, by the second week in August, it was very severe in many localities. At that time, other species showing drought effects were aspen, large-toothed aspen, sugar maple, hazel, and service berry. To the northwest of Copper Cliff, as far as Cartier, no drought symptoms were observed. It is suggested that this section had the benefit of rains which did not fall in other localities. Again no symptoms of injury caused by sulphur dioxide were observed in the Temagami Forest Reserve, which contains extensive stands of white and red pine of great scenic and commercial value. Six automatic sulphur dioxide recorders were operated in the Sudbury district in 1946 and the records, when analysed, should give a comprehensive picture of the distribution of gas in the general area.

Dutch Elm Disease.—At the Central Laboratory 1,302 collections of specimens from trees suspected of having Dutch elm disease were received for culturing. This total included 298 collections, from suspected trees in Richelieu county, which were sent in from the Quebec Department of Lands and Forests. A much larger proportion of "beetle material" i.e., small pieces of bark or wood in which bark beetle galleries are present, was received than during 1945. The fungus which causes the disease may be found in such material before the tree shows any symptoms of infection. Beetle material and branch samples formed the greater part of the material received, but there were in addition slabs of wood showing stain taken from the trunks of a number of trees. The kind of material received and the results obtained from culturing it are shown in the following tables.

THE KIND OF MATERIAL COLLECTED AS SAMPLES FROM 1,302 TREES SUSPECTED OF HAVING THE DUTCH ELM DISEASE

Kind of material	Number of Samples			
	Ontario	Quebec	New Brunswick	Total
Branches	41	803	9	853
Trunk	1	117	0	118
Root	0	1	0	1
Beetle material	138	183	2	323
Branches and beetle material	9	11	0	20
Trunk and beetle material	0	10	0	10
Branches and trunk	0	6	0	6
Totals	189	1,131	11	1,331†

† The total number of samples includes 29 re-collections.

RESULTS OF CULTURING SAMPLES FROM 1,302 TREES SUSPECTED OF HAVING THE DUTCH ELM DISEASE

Fungus isolated	Number of trees from which samples were obtained			
	Ontario	Quebec	New Brunswick	Total
Ceratostomella Ulmi	0	560	0	560
Cephalosporium	12	168 (+5)*	0	180 (+5)*
Verticillium	7	15	0	22
Miscellaneous	18	128	5	151
Sterile	10	33	4	47
Negative	132	211	2	342
Totals	179	1,112	11	1,302

* Five samples yielded *C. Ulmi* or *Verticillium* as well as *Cephalosporium* and have been counted under those fungi.

Scouting for Dutch elm disease was carried on as formerly by the Division of Plant Protection, Science Service, and the Quebec Department of Lands and Forests. The results show that the disease is still confined to Quebec and that there was some extension of the infected area to the northeast and to the west and southwest as compared with the preceding year. However, it is uncertain whether or not this greater distribution of the disease represents spread since 1945. In 1945 a total of 1,321 infected trees were located and destroyed. This year about 2,100 diseased trees were found and about 1,400 of these have been taken out. Owing to the high incidence of the infected trees in the central part of the infected area the policy of removing all diseased trees as a measure of control had to be abandoned and control work was confined to the outer districts.

Investigations at Petawawa.—A project on heartwood decay of poplar has been completed for this locality, and the results are now in preparation for publication as a departmental bulletin. It was found that the percentage volume of decay is not affected by site within the range of local conditions. The absolute volume of high quality wood, however, is definitely related to site conditions. The disease does not cause serious losses, on a volume basis, in stands younger than 70 years. At this age, on favourable sites, the periodic increment of sound wood continues to increase. Curves were constructed to aid in the estimation and prediction of sound volume and percentage decay in stands of all age-classes. The production and viability of spores of the causal fungus (*Fomes igniarius*) were studied in relation to season and to meteorological conditions. The results have a practical bearing on the silvicultural treatment of poplar stands. It was demonstrated that this fungus is capable of attacking living trees through wounds not only in the heartwood, but also entirely within the sapwood region. Girdling was compared with felling as a means of disposing of badly diseased trees. The former proved to be the more effective method. Comparable investigations into this disease should be undertaken in other regions as soon as possible.

As part of the tree breeding (co-operative) project of the Dominion Forest Service, observations were continued on rust attack in several hundred lots of poplar breeding materials in nurseries and plantations.

Blister rust of white pine, a serious disease first introduced into North America about 50 years ago, has now attained a stage of development where appreciable losses in commercially mature pine stands are being caused in this region. Analysis of sample strips through two stands at the Petawawa Forest

Experiment Station and in Algonquin Park, indicates that not less than 15 per cent of the trees are fatally attacked. Some of these have already been killed. There is no question that this destruction will continue to increase unless preventive measures are practised. The disease can be held in check by the local eradication of currant and gooseberry bushes, the alternate hosts of the rust fungus. Recommendations to this end have been made to the Ontario Department of Lands and Forests and to the Dominion Forest Service. A number of locations have been selected for further studies in 1947.

In 1941, a six-year-old red pine plantation was found to be seriously attacked by a disease that stunted growth and killed individual branches and leaders. This disease has since been identified as that caused by the combined attacks of a fungus (*Diplodia pinea*) and a spittle bug. Re-examination of the stand in 1946 revealed that the disease has become apparently inactive, and the surviving trees are flourishing. There is still evidence of the effects of the attack, namely, numerous dead branches and leaders still in position, and a series of suppressed growth rings and healed or partly healed scars. It appears that under favourable conditions, affected stands are able to overcome this disease and recover, without the aid of artificial treatment.

Cultural Studies of Wood-Rotting Fungi.—During 1946, 437 accessions were made to the collection of wood-inhabiting fungi in the Mycological Herbarium. These include 172 Agaricaceae, 82 cultures for which specimens of sporophores or rots were not received, and 183 other Hymenomycetes. The number of entries in this section of the Mycological Herbarium now stands at 12,980. A request for an exchange of specimens was received from the Naturhistoriska Riksmuseet at Stockholm, Sweden, and 100 exchange specimens were sent. Of the specimens added to the herbarium, 73 were submitted for identification by the Dominion Laboratory of Forest Pathology at Victoria, B.C.

The collection of cultures of wood-decaying fungi was increased by the addition of 153 new cultures, of which 89 were named, and 64 were still unidentified, while five cultures were discarded. The collection now contains 1,265 named cultures, representing 340 species in 62 genera, with 256 still awaiting identification. Approximately 360 cultures isolated in decay studies of coniferous trees in British Columbia during the 1946 field season and not yet identified are not included in the above totals. Series of monosporous mycelia are maintained for 46 species, and for 34 isolates that are still undetermined. In answer to requests from correspondents, 72 cultures were sent out during the year.

During 1946, identification of cultures isolated from rots encountered in the decay studies made on various species of coniferous trees in British Columbia by the Dominion Laboratory of Forest Pathology, Victoria, was continued, 463 isolates having been determined. Identification of 159 isolates from alpine fir demonstrated that 26 species of fungi were associated with decay in this host. Identification of 196 cultures from decay in western hemlock brought to 32 the number of species isolated from that host. Twenty-two of the cultures isolated from decay following scar injury in western white pine were identified, and all proved to be either *Fomes Pini* or *Stereum sanguinolentum.*

Investigations in the Maritime Provinces and Quebec.—The high mortality in yellow, white, and grey birch in the Maritime Provinces, eastern Quebec, and the Northeastern States has caused widespread concern as to the future of these species. First reported in 1935 in central and southern New Brunswick by the Dominion Entomological Laboratory, Fredericton, N.B., the epidemic appears to have spread steadily until at present it is estimated that most of the merchantable birch in New Brunswick, the western counties of Nova Scotia, northern Maine, and eastern Quebec is in a dead or dying condition. The threatened disappearance of merchantable stands of yellow birch, in particular, in Eastern

Canada represents a considerable financial loss, since this species is highly regarded as a source of veneer, as well as of lumber and ties, and forms an important component of eastern forests.

The cause of the epidemic is by no means fully understood. Most trees, at least those in the advanced stages of dying, have been found to be infested by the bronze birch borer (*Agrilus anxius* Gory). Presumably this insect can successfully attack and kill only trees in a weakened condition, but the possibility must not be overlooked that, when the insect population reaches a sufficiently high level, initial attacks in numbers on vigorous trees may eventually be successful. Furthermore, the selective cutting of softwoods over large areas in mixed stands with birch, which is notoriously sensitive to such disturbance, have provided large numbers of weakened and overmature birch trees to encourage a great increase in the insect population. Consideration must also be given to the possibility that meteorological or pathological factors may be responsible for predisposing birch to insect attack and eventual death.

There is some evidence that a die-back of the twigs and branches of birch may occur in the absence of the bronze birch borer. To determine the cause and prevalence of this die-back condition and its importance in connection with insect infestation, preliminary field studies were undertaken in 1946 in Pictou County, Nova Scotia. Here die-back without the complication of insect attack is not uncommon. Although a number of fungi have been isolated from dead or dying branches, none are known to possess aggressive pathogenic capabilities. It is proposed to continue this work in greater detail and also to investigate the possibility that a root disease may be responsible for the die-back condition.

White pine blister rust is known to be widely established in the Maritime Provinces and, although the damage caused by this disease to trees of merchantable size is generally recognized, its importance as a possible cause of the lack of white pine reproduction is not fully appreciated. In one small white pine stand in the vicinity of Fredericton, N.B., a large proportion of the mature trees examined during the latter part of May showed side branch cankers and some were found with main stem cankers. The most noticeable effect of the disease was the lack of advanced reproduction. Saplings with white pine blister rust cankers succumb relatively quickly as a result of girdling, usually in the lower part of the main stem. A number of such cankered trees were found with the causal fungus in an actively sporulating condition. The source of infection was traced to a nearby patch of wild currants, and eradication to prevent further infection of the white pines was recommended. Further study of the effect of this disease on white pine reproduction in the Maritimes is indicated.

The importance and magnitude of salvage operations in fire-killed pulpwood stands can be readily appreciated when it is considered that in the province of Quebec alone some 2,485 square miles (over 1,500,000 acres) of pulpwood forests were burned over in 1941. The rational planning of salvage operations for these killed stands is dependent upon reliable prediction of deterioration caused by decay and windfall breakage after fire. Examinations of plots in the St. Maurice, Lake St. John, and North Shore regions of Quebec in connection with the study of the rate of deterioration of fire-killed pulpwood stands were again made in 1946. These plots, established following the widespread fires of 1941 and examined annually, have yielded more definite information on the effect of severity of fire and the effect of species and site conditions, than was heretofore available. A report on the results of this investigation is in press. It is believed that this information will be of value to companies operating in burned-over stands in the planning of the most economical salvage program.

Branch Laboratories

Charlottetown, P.E.I.

Potato production reached record proportions in 1946, a total of approximately 9,000,000 bushels of seed and table stock being graded for export sale. This expanding industry thus draws increasingly upon the resources of this laboratory for a solution to pressing problems and guidance on matters related to the elimination of crop losses due to destructive diseases. Aid to potato growers rendered in an advisory capacity chiefly concerned the control program for late blight, diagnosis and eradication of bacterial ring rot, and recommendations regarding magnesium deficiency, common scab, virus diseases, and potato storage disorders.

Weed identification and recommendations on control constitute another important service to farmers. In addition, each member of the laboratory staff has participated in farmers' meetings, radio broadcasts, field days, Provincial Government and Veterans' short courses in the past year.

In 1946, ten spray and dust materials were tested for the control of late blight of potatoes. Two types of tribasic copper sulphate, one micronized and the other machine ground, were tested; the former proved highly efficient, but the latter was unsatisfactory. Dithane, a non-copper material, compared favourably with the various copper products under test. Low-lime bordeaux mixture has surpassed all other chemicals in fungicidal effectiveness. The results have been so favourable that Prince Edward Island farmers are now advised to use 4-2-40 bordeaux for the summer sprays and 4-1-40 for the late-season applications. Bordeaux mixtures in which the amount of hydrated lime is not greater than one-half the amount of copper sulphate are most effective against late blight and the plants so sprayed give the highest yields.

Destruction of potato tops prior to digging the crop is a practice that has been successfully introduced among potato growers; the demand for top-killing materials greatly exceeded the supply in 1946. The advantages of this practice include virus disease control, prevention of late-blight tuber rot, control of tuber size, and advance of digging date, which avoids low temperature injury and secures a crop for the early market. The products, Dowspray, G-502, and Sinox General gave very rapid kill, with no apparent deleterious effect upon the tubers. Sodium arsenite, although somewhat slower acting because of lime residue on the foliage, has given satisfactory results. To meet the full requirements of a top-killing agent the chemical must be inexpensive, rapidly effective, non-injurious to the soil, not harmful to the operator, and should not affect the keeping quality, sprouting, flesh colour, or flavour of the tubers.

Investigations have been continued on magnesium deficiency in potatoes. Fields most severely affected showed a soil reaction of pH 4·6 to 5·0. Dolomitic limestone applied as a means of correcting this relatively high acidity is a satisfactory corrective for this deficiency disorder. Magnesium sulphate spray was moderately satisfactory and gave increased yields. Magnesium oxide, as a soil amendment, was moderately effective at 20 pounds per acre and most satisfactory at 80 pounds. Yields increased substantially at application rates up to this figure.

Potato rot nematode investigations conducted in co-operation with other Science Service officers, have revealed valuable information on the behaviour and control of this parasite. Dowfume soil fumigant W-10 has given almost complete eradication. Extensive host range studies established the susceptibility of field mint. Although this common weed has wide distribution throughout the province, diseased plants have not been found outside of the nematode-infested area.

Kentville, N.S.

Advice on orchard spraying based on the seasonal activity of the fungus causing apple scab was sent through the Nova Scotia Fruit Growers Association to all local papers and radio stations. The fungus was most active between the mouse-ear and full-bloom stages of tree development but a light ascospore discharge continued until early July. Weather conditions from June onwards favoured the production of a clean crop of fruit.

Comparative tests with lime-sulphur iron sulphate, flotation sulphur (ferrox type), Fermate, wettable sulphur, Phygon, Puratized N5E and Isothan Q15 on apples, indicated that the first five materials gave satisfactory control of apple scab in 1946 on Gravenstein, McIntosh and Cox Orange. Russeting of Cox Orange fruit was slightly less in the Fermate plot than in the other treatments.

Ground spraying an apple orchard area with a dinitro-cresol suspension reduced the number of viable spores, but did not permit a reduction in number of fungicide applications to the orchard.

Apple mosaic has increased during the past seven years, from 24 to 37 per cent of the trees in an observation orchard, under normal orchard practice. No grafting has been done during this period.

Whereas storage rots of apples in the 1945 crop were largely caused by *Gloeosporium album,* this fungus was rarely found in stored fruit from the 1946 crop although present on twigs in the orchard during the early summer. The extremely moist weather during 1945 appeared more favourable to the fungus than the comparatively dry season of 1946.

A series of potato spray plots comprising 21 treatments applied in quadruplicate showed the effects of various insecticide and fungicide combinations. An average increase of 45·7 bu. per acre was obtained with DDT over calcium arsenate in the same fungicides. Bordeaux 10-2½-100 had a significantly depressing effect on yield. All plots treated with carbamate materials plus DDT gave higher yields than the bordeaux 10-5-100 or bordeaux 10-10-100 with DDT. Although benzene hexachloride gave satisfactory control of flea beetles, etc., the tubers from treated plants had a disagreeable musty flavour even after five months storage. No data were obtained on disease control as neither early nor late blight appeared in the plots.

Observations made on potato tuber blemishes in a crop rotation experiment conducted by the Experimental Station, Kentville, indicated that more *Rhizoctonia* sclerotia were found on tubers from continuous cropping areas than from rotation areas.

An increase in the planting of canning peas in Nova Scotia during 1946 prompted some seasonal surveys of this crop. Seed samples were tested in the greenhouse and several lots were recommended for and subsequently given a seed treatment of Spergon before planting. Root-rots caused by *Fusarium* spp. were of minor importance except in one small field in Pictou county. A comparatively dry summer reduced foliage diseases to a minimum. Factors such as weeds, dry soils, depth of planting and aphids reduced the crop in many fields.

Fredericton, N.B.

An analysis of the viruses in Green Mountain stocks from six provinces has revealed that most sources of this variety, including Foundation and Certified stocks, have acquired a virulent strain of the so-called latent virus. This virus gives rise to a mild form of mosaic, which intensifies when the plants so involved are maintained for prolonged periods at temperatures from 60 degrees to 70 degrees Fahrenheit with a relative humidity ranging from 55 to 70 per cent. Most of the original stocks of the Green Mountain variety

harbour only a weak strain of the latent virus. The stocks bearing the weaker strain were found to be more productive than those harbouring the virulent form of the virus. The potatoes bearing the weak strain are considered more satisfactory for Foundation and Certified seed. There are also some indications that the stocks bearing the virulent form of the virus are more susceptible to net necrosis when they become infected with the leaf roll virus (Solanum virus 14).

Field trials conducted on a semi-commercial basis following a regular schedule (eight applications) of DDT (50 per cent) and Gammexane, in spray form, gave satisfactory commercial control of aphids serving as vectors of virus diseases, but failed to effect adequate control of the leaf roll and mild mosaic transmitted by these insects. In certain cases, there was more virus disease in the treated plots than in the untreated checks. This indicates that these insecticidal treatments were ineffective in preventing viruliferous aphids from introducing the viruses to the potato plants although these plants received weekly applications of these insecticides. A high measure of control of leaf roll and mild mosaic was effected when potatoes, including the Green Mountain, Irish Cobbler, Bliss Triumph, and Katahdin varieties were planted early, thoroughly rogued, and harvested before viruliferous aphids were able to effect transmission of the viruses to the plants.

During 1946, 214 seedlings were tested in the greenhouse and 216 seedlings were examined under field conditions for resistance to leaf roll (Solanum virus 14). Two of these seedlings have shown no evidence of leaf roll during the four years they were under test. They appear to have a high degree of resistance to the virus under field conditions. Hybrids of *S. demissum* × *S. tuberosum*, 11,549 in all, were tested for their resistance to late blight infection. Approximately 46 per cent of the seedlings were immune or highly resistant to vine infection and 54 per cent were susceptible. The tuber resistance of 310 of the most horticulturally desirable of these seedlings was also determined and 124 of these were found to bear blight-immune tubers. The common-scab resistance of 1,169 seedlings, representing 43 crosses, was also determined. About 12 per cent of these produced tubers highly resistant to scab infection. A number of the most promising leaf roll, blight, and scab resistant seedlings are undergoing field trials at selected stations in the Dominion.

Extensive spray tests were conducted to determine the protective value of the many spray materials now available for the control of potato late blight. Nineteen fungicides—including organic, neutral and fixed copper compounds in combination with two commercial forms of the insecticide DDT—were tested. Due to seasonal conditions no blight developed in the plots. The insecticides Deenate (50.W) and J. P. 70 gave excellent control of the Colorado beetle and the flea beetle with all the fungicides tested. The highest yields were obtained with Zerlate combined with 4-2-40 bordeaux, and Dithane and Basicop.

There is a growing demand by apple growers for fungicidal or fungistatic spray materials that are safer to use and less harmful in effect than the bordeaux and liquid lime-sulphur sprays commonly used for the control of apple scab. Nine spray materials—including puratized, dry lime-sulphur, potato psyllid spray, mulsoid sulphur, Omilite, Fermate, Glyoxaldine, Isothan Q15, and Karbam—were tested under orchard conditions. Each spray was applied at the pre-pink, pink and calyx stages of apple development. All the plots were sprayed with Fermate at the height of full bloom. At the time of petal fall the Omilite, Glyoxalidine, and Isothan Q15 sprays failed to control satisfactorily leaf scab and were replaced by the more eradicant Puratized or dry lime-sulphur sprays in the first cover application. The potato psyllid spray was discontinued after the calyx spray because of excessive leaf injury to the trees. The second and third cover sprays applied to all plots consisted

of a 5-15-100 bordeaux. The Puratized, dry lime-sulphur, mulsoid sulphur, Fermate, and Karbam sprays gave excellent control of scab and little, if any, russetting.

During wet seasons, scab of cucumber and late blight of tomatoes are often limiting factors in the production of these crops. Although commonly recommended, bordeaux mixture usually fails to effect a good control of cucumber scab and adversely affects the tomato plant, greatly inhibiting the ripening of fruit. An attempt was made to control scab on thirteen varities of cucumbers, utilizing a schedule (six applications) of Isothan Q15, Phygon, and Puratized in spray form. Due to dry weather no scab developed in the plots. However, it was demonstrated that all these sprays injured the plants to some extent, by destroying the leaf tissue or stunting the vines. The plot treated with Puratized and the check showed the highest yields. The yield was depressed in the plots treated with Isothan Q15 and Phygon. The tomato plots were sprayed six times with Phygon, Puratized, Dithane, and 4-1-40 bordeaux. Despite its low lime content, the bordeaux spray caused considerable injury to the plants. This was reflected in the damage to the floral structures, reduction in leaf surface, and stunting of the vines. However, due to curtailment of leaf development, this plot produced the highest percentage of ripe fruit. No late blight developed in the plots. All the treated plots out-yielded the checks.

A recent development in potato production is a demand for a chemical spray or dust that will rapidly and economically kill potato vines, thus enabling early harvesting to curtail the field spread of virus disease, to combat late vine growth resulting from the use of DDT sprays, and to reduce to a minimum late blight infection at digging time. In this regard four vine-killing compounds, namely, Handy-Killer, Aero cyanamid, Dowspray 66 Improved, and Sinox General were tested on seven potato varieties. The applications were made on various dates, beginning August 10. In these trials, Dowspray 66 Improved and Sinox General, at the prescribed rates, killed the vines in 24 hours or less. Handy-Killer, when used at double the concentration usually recommended, was effective and rapidly killed the vines. Aero cyanamid was slow in action and only effected complete killing after a 5-day interval. Sinox General and Dowspray 66 Improved, when applied to the vines at the recommended rates late in the season, caused considerable internal discoloration of the tubers.

Ste. Anne de la Pocatière, Que.

The formation of perithecia of apple scab (*Venturia inaequalis*) was favoured by a mild fall and the absence of alternate freezing and thawing during the winter. Perithecia were abundant in the spring of 1946, but low temperatures and humidities made ascospore discharge scanty. Consequently, scab was not noticeable until August, and only became heavy during wet weather in September.

Studies were continued on the epidemiology of late blight (*Phytophthora infestans*) of potato. Attempts to start primary infection in the field from diseased sets were unsuccessful owing to unfavourable weather conditions. The majority of sets, naturally or artificially infected with the fungus, produced uniformly healthy shoots; the rest rotted in the soil. Small refuse piles distributed in the field did not cause any late blight infection, although the fungus was observed on the surface of a few rotted tubers during summer. There was no late blight reported throughout Quebec, except from Chicoutimi, Lake St. John, and Douglastown in Gaspe, where there were moderate infections in a few fields. The pathogen was isolated from tubers received from various potato centres in Eastern Canada. Among the few isolates that were tested, some have shown slight differences in virulence, growth rate, and degree of sporulation.

Some evidence was obtained that *Corynebacterium sepedonicum*, the cause of bacterial ring rot, did not overwinter on potato planters, under the conditions of 1945-46. Certified seed potatoes were planted with a machine that had been used the previous year for planting potatoes infected with ring rot. The planter had remained in a shed throughout the winter and was used without disinfection. No disease resulted from this operation.

Studies on the rate of movement of ring rot bacteria in potato plants showed that the pathogen travelled more rapidly downward when inoculations were made at the upper end of the stems and in petioles than when inoculations were made lower in the stems and in the midribs.

The rate of spread of virus diseases varies between and even within districts. Plots were established in 1945 with indexed potato tubers on 27 farms located throughout the province, from the Eastern Townships to the north and south shores of the lower St. Lawrence. Eyes from the same tubers were planted in the same sequence in several localities. In the fall two tubers from each hill were stored and were planted the following spring, one tuber in the original locality and the other on a farm in the lower St. Lawrence where the crops from all localities were compared. From observations made in 1946, it appears that virus infection in 1945 was over 80 per cent in one locality and over 50 per cent in two others in the Eastern Townships and Nicolet. In a few localities on the lower St. Lawrence there was no increased infection.

A test has shown that growing potatoes infected with virus diseases for seven consecutive years has reduced yield considerably. Leaf roll reduced the yield 63 per cent, severe and rugose mosaic 35 per cent, and mild mosaic 27 per cent.

Potatoes that were eye-indexed in the greenhouse were planted in the field after eliminating the diseased tubers. A certain number of these supposedly healthy tubers produced one to several plants affected with virus diseases, showing that eye-indexing may not completely eliminate viruses from a lot of potatoes. These results, added to those obtained when every eye was planted from a lot of tubers known to be virus-infected, show that virus expression may vary considerably in plants originating from the same tuber.

Seed disinfection tests for the control of seed-borne and soil-borne diseases of fibre flax were conducted on light gravelly soil. The treatments were as follows: Ceresan 1½ ounces per bushel, Arasan, Spergon, and Phygon 2 ounces per bushel, and check (no treatment). Tow, seed, and fibre yields showed no significant differences between the check and the various treatments. However, yields were low, and varied considerably.

A die-back was observed in several flax fields. At flowering time the tops withered and turned brown and the trouble progressed slowly downward. Numerous attempts to isolate a pathogen yielded no organism but some gave *Alternaria tenuis* or other saprophytes. Inoculation tests with these organisms were negative, indicating that the disease may be physiological.

An experiment to study the effect of field spraying on yield and control of tomato diseases was carried out for the fourth year. The fungicides used in 1946 were: Phygon, COCS, Zerlate, Fermate, Dithane, Puratized. The check was sprayed against insects. Zinc sulphate-lime (1-½) was added to all spray solutions except Puratized. A bacterial leaf spot was controlled by all treatments except Zerlate. Phygon caused leaf injury. Anthracnose (*Colletotrichum phomoides*) and late blight (*Phytophthora infestans*) fruit rots were decreased by the regular applications of all ingredients except Puratized, which increased the percentage of rotted fruits as compared with the check. Spotting on stored fruits, caused by *Phoma* sp., was controlled by all treatments except Dithane.

The total number and yield of fruits (green and ripe) obtained with the different treatments and check were not significantly different. The same was true of marketable (U.S. No. 1 and No. 2) fruits. The number and yield of U.S.

No. 1 fruits were reduced by Phygon and COCS as compared with the check. Copper sprays are considered the best fungicides because they provided a better control of defoliating diseases, late blight and *Phoma* fruit rots. However, they were inferior to Fermate for the control of anthracnose, when this disease was prevalent.

St. Catharines, Ont.

The season of 1946 was favourable for fruit production. Generally, losses due to disease were kept at a minimum by the effective application of recommended control measures.

A sudden outbreak of late blight on tomatoes in the latter part of August caused severe losses to the canning crop. In many fields, only one picking of fruit was possible and in others all the fruit was lost. The disease was most severe in plantings set with southern grown plants.

Control of Apple Scab.—In the spray experiment 17 treatments were tested. Weather conditions permitted the eradicative value of the fungicides to be clearly demonstrated. Both lime sulphur 1-60 and Puratized 1 pint-100 gal., applied after a 20-hour infection period, were very effective in checking scab development. Puratized, applied even a week after a critical infection period, greatly reduced scab development and caused no injury to the foliage.

Dry elemental sulphurs in the same experiment permitted abundant scab development. To be effective, they require liberal dosage, frequent coverage and timely application in relation to prolonged rainfall. Better scab control was obtained with Flotation sulphur paste and by the addition of a sticker-spreader to the dry elemental sulphurs. Omilite (polyethylene polysulphide), used in 1946 for the first time, was very effective as a sticker with micronized sulphur. In this experiment, the organic fungicides, Fermate, Karbam, Isothan, and Omilite, were not effective in preventing heavy foliage scab.

Bordeaux was an excellent "finish off" spray in the late cover sprays. Lime sulphur 1-75 failed to protect the fruit from mid and late season infection. Flotation sulphur paste and Mike sulphur were the best elemental sulphurs, but the percentage of scabby fruit was too high for commercial standards. Fermate and Karbam, on the other hand, proved to be very effective cover sprays. Despite severe foliage infection of the trees, the percentage of scabby fruit was low. Isothan and Omilite were ineffective.

Control of Cherry Leaf Spot.—The spraying experiment for the control of leaf spot of sour cherries concerned the value of fixed copper fungicides and the organic material Phygon. The disease proved of very minor importance in the orchard until late in the season when a moderate infection developed. All the materials afforded good protection, but induced more or less yellowing and casting of leaves. This injury was less pronounced with Bordow, Copper A Compound, and Phygon, than with COCS, Cupro K, Basicop, and Spraycop. Phygon was found to cause a mottling of the foliage and a dwarfing of the fruit.

Brown Rot of Cherries and Plums.—Spraying experiments for brown rot were not conclusive in either the blossom-blight or fruit-rot phases of this disease. Sprays applied to sweet cherries, sour cherries, and plums at intervals during bloom yielded little information because of the very scattered and low incidence of blight (1·6%) that developed on unsprayed trees. The slight differences recorded suggested that wettable sulphur was a preferable fungicide to Zerlate and Omilite and that applications previous to full bloom were more effective than later ones.

Brown rot of the fruit was negligible in cherries. In plums, it was a factor only on Lombard and Imperial Gage varieties. Summer spray schedules employing Magnetic sulphur paste, Microflotox, and Sulfuron X were effective in controlling fruit rot.

Raspberry Inspection and Certification.—The annual inspection of raspberries for certification of planting stock covered 122 plantings on the premises of 23 growers. Twelve of these plantings were rejected because of the incidence of virus disease. The number of canes for which official tags were issued for fall shipment totalled 378,675, an increase of 130,000 over 1945.

Pear Scab.—Applications of Puratized (5% active ingredient), 1 pint in 100 gal., at petal fall and twelve days later reduced foliage scab infection from 21·5 to 2·0 per cent on the very susceptible Flemish Beauty variety. Puratized was considered promising for use on this host in a split schedule to provide more satisfactory control of this disease.

Brown Rot of Peaches.—In 1946, in experiments conducted in co-operation with the Horticultural Experiment Station, Vineland, Ont., triplicate samples of peaches from three successive picks of Valiant and two of Elberta were examined periodically for brown rot at Vineland, Toronto, and St. Catharines. Comparison of data from these observation points indicated that the general level of brown rot incidence varied from place to place and from pick to pick, and that the effects of spray treatments were consistent throughout. In general, control with different brands of sulphur and with Fermate was as efficient at the end of the harvest season as at the beginning. Zerlate (zinc dimethyl dithio carbamate), however, did not retain its efficiency throughout the harvest season.

Single sprays, at bloom or at three weeks before harvest, gave no control of brown rot. There was evidence that an extra spray in mid-season or during harvest improved control when conditions at the time of application favoured brown rot. On the whole, results confirm the view that the regular spray program recommended for peaches in Ontario should be regarded as the basic minimum schedule to which extra applications should be added at critical times.

The transparent basket coverings in general use in Ontario in 1946 were made of water-proof plastics with $\frac{1}{4}$-inch perforations at one-inch intervals. The condensation of water on the underside of the cover when the packages were cooled proved to be an objectionable feature. This disadvantage can be overcome by doubling the diameter of the perforations in water-proof materials or by using a non-water-proof material, such as cellophane, in which perforation is unnecessary.

It was feared that the condensation of moisture on the transparent covers would markedly increase wastage from brown rot. However, several experiments on this phase showed that the amount of brown rot under the transparent covers did not differ to any great extent from that found in leno-covered baskets. The non-perforated non-water-proof cellophane compared favourably with leno in this respect, except during protracted holding in damp weather.

Sample baskets were selected at random from packs of nine growers before and after shipment in an iced car to Fort William, Ontario. Records of brown rot development during the first week or ten days after harvest were taken at Vineland, St. Catharines, and Fort William. There was a remarkably close agreement in the behaviour, at the three observation points, of peaches from the same source, but a wide divergence between the packs from different orchards. Careful comparison of data indicated that brown rot was delayed by two or three days by refrigeration in transit. Brown rot wastage could not be correlated with the maturity of the sample. As it happened, the least mature pack showed most brown rot, while the ripest one was about half way down the list. It was thus evident that the level of wastage in any given pack depended mainly on what happened to the fruit in orchard and packing shed before it was put into the basket.

Virus Diseases of Stone Fruits.—Several strains of Montmorency and Napoleon cherries, Lombard plum, and Italian prune have given no indication

of virus infection in two successive trials. Arrangements have been made with the Horticultural Experiment Station, Vineland, for the propagation of these disease-free stocks for eventual distribution to the trade.

Virus disorders closely resembling the peach necrotic spot described by Cation in Michigan, have been found latent in some sweet and sour cherry varities and in some European and Japanese plums indexed on peach in Ontario. On peach, the annually recurrent symptoms are fine mottling, vein banding, and rings, followed by varying degrees of necrosis, on the leaves in June or July. This group of diseases is distinct from other diseases of plums and cherries, such as necrotic ring spot, tatter leaf, and line pattern.

Necrotic ring spot has been recovered from artificially inoculated peach trees in which the disease had been masked for five years. Crop records on Montmorency indicate that delayed and uneven ripening and some reduction in yield can be expected from trees affected with this disease. The time of leaf fall has not been appreciably affected by necrotic ring spot.

Tatter leaf symptoms on Montmorency have shown characteristics in common with both necrotic ring spot and cherry yellows; but indexing on peach gave no indication of the presence of either of these diseases, the reaction being typical of tatter leaf.

Delayed and uneven ripening, varying reduction of crop and premature defoliation were associated with tatter leaf in Montmorency. Other experiments have demonstrated the possibility that sweet cherries can be affected with necrotic ring spot and tatter leaf, either singly or in combination. This finding may explain some of the conflicting results obtained by different workers with diseases of sweet cherries of the tatter leaf type.

Some milder strains of the prune dwarf virus tend to remain localized in the tree for some time, whereas other strains induce systemic infection a year or so after inoculation. Because this disease can be carried in latent form both in sweet cherry and in most plum varities, its distribution in Ontario is probably much wider than is at present realized.

Potato Diseases.—Preliminary tests with chemical vine killers were made on two fields in the fall of 1946, one at Brantford, and the other at St. Catharines. Three different chemicals, Sinox General, Dow 66, and Krenite with ammonium sulphate, were used on Chippewa potatoes at Brantford and all produced severe vascular discoloration in the tubers, evident at digging. Where discoloration was present, the browning was not confined to the stolon end, but almost invariably extended throughout the vascular ring and was often most severe at the eye end of the tuber.

At St. Catharines, the test was made on Katahdin potatoes and, in addition to the three chemicals used at Brantford, five others were used, viz., sodium arsenite, cyanamid (both as a dust and a spray), copper sulphate, and Herbate (a 2, 4-D preparation). None of the materials used in this test, when applied on either Sept. 18 or Oct. 4, produced serious discoloration.

The wide variation in the severity of the discoloration in these two tests was unexpected. At Brantford the application of the chemicals was followed by a heavy rain the next day, whereas at St. Catharines it was followed by a week of clear, sunny weather. These differences in conditions at the two places may have had a bearing on the variation in the amount of discoloration.

Two successive crops of potatoes, oats, rye, wheat, timothy, clover, corn and soybeans were grown in pots of soil which had produced a crop of severely scabbed potatoes in 1945. In each series after the second crop had been thoroughly incorporated with the soil, scab-free potato sets were planted.

The tubers grown in pots that had been kept fallow and those in the soil which had previously grown potatoes were severely scabbed with large deep lesions; those in the pots where soybeans had been grown were the cleanest,

having only a few small lesions; and those following rye, were the next least severely infected. No consistent reduction in infection could be observed following any of the other crops. The reduction in the incidence of scab following the soybean crops was correlated with a reduction in the pH and increase in the nitrate and potash levels of the soil.

For the third consecutive season inspectors of the Ontario Department of Agriculture made an extensive survey of the province to locate fields infected with bacterial ring rot. All samples collected in the province south of North Bay and west of Kingston were sent to St. Catharines for identification. In all, 530 samples were received, of which 384 were positive for ring rot. These figures show a considerable increase over the past two years, probably due to the larger number of inspections made rather than to an increase in the amount of the disease.

The co-operative project on spraying and dusting of potatoes was continued in 1946 in Brant county. Plot sizes and replications remained the same as in 1945, but the number of treatments was increased from 30 to 40. Ten applications of sprays or dusts were made at weekly intervals between July 3 and September 3. No DDT was applied to controls or buffer plants. Conditions did not favour severe outbreaks of insects or diseases. Some foliage injury was caused by bordeaux mixture, but luxuriant foliage resulted from treatment with the organic fungicides. In general, the yields varied little, but they were reduced substantially by Phygon.

Potato spray tests were carried on at the laboratory primarily to test two factors: the compatibility of burgundy mixture with DDT, and the effectiveness of a 3 per cent DDT-copper-lime dust in the control of leaf hoppers. Burgundy mixture proved compatible with DDT and comparable to bordeaux mixture with DDT. The free lime present in copper-lime dust destroyed the insecticidal effect of the DDT almost completely.

To obtain additional information on the effect of various spray and dust materials in combating potato blight and insect pests, five field tests on one-acre plots were carried on in different localities. Although foliage diseases were insignificant on all farms, leaf hoppers were prevalent and materially reduced yields where DDT was not used.

Tomato Diseases.—In 1946, ten fungicides were tested for the control of Alternaria and Septoria blights. Five applications were made at ten-day intervals beginning July 24 and disease readings were taken September 8. Defoliation from blights ranged from 40 to 91 per cent with the different fungicides in comparison with 80 per cent for the unsprayed plot.

Black Pod Blotch of Radish.—Greenhouse experiments indicate that seed treatment with 1 per cent Ceresan dust may reduce seedling blight by 25 to 40 per cent. Arasan and Spergon dusts were less effective. Low soil moisture tends to reduce lesioning of seedlings and makes temperature effects unimportant. With high soil moisture, infection was less between 18° to 23°C. than at higher or lower temperatures. It is recommended that seed be treated with a 1 per cent Ceresan dust and sown early enough to allow harvest of the seed crop before cool wet weather of late summer sets in. A study of over 300 single spore isolates indicates the existence of numerous strains of the causal organism, *Alternaria Raphani.*

Harrow, Ont.—Investigations on blue mould of tobacco indicated that, although there appeared to be definite evidence of the fungus overwintering in the tobacco belts of both Essex and Norfolk counties, there was also abundant evidence of widespread infection by wind-borne spores from the northern tobacco-growing areas of the United States. Tests indicated that a measure of blue mould control could be obtained in the A-type seed-beds of the new tobacco belt by shutting them tightly and allowing the temperature to rise to approxi-

mately 105°F. during successive periods of several hours each. Apparently, however, humidity in the greenhouse at the time of the test affected the efficacy of this treatment, best results being obtained where plants were relatively dry during the period of higher temperature.

Field experiments to determine the relationship of source and amount of nitrogen in the fertilizer to incidence of brown root-rot of tobacco yielded interesting results. When both resistant (Green Briar) and susceptible (Halley's Special) burley varieties were grown on brown root-rot soil, the yield of the latter was increased as much as four times by the optimum application of fertilizer, whereas the yield of the former was only doubled. Yield of susceptible varieties was extremely low in brown root-rot soil where the fertilizer contained no nitrogen. In these experiments ammonium nitrate and nitrate of soda provided the best sources of nitrogen. It was concluded that if susceptible varieties of burley tobacco are grown on soils subject to brown root-rot, it is highly important to provide adequate levels of nitrogen in the fertilizer.

Studies of the relative resistance of burley tobacco varieties to brown root-rot were continued; marked differences appeared both in locally-developed and in certain introduced strains.

Investigations on the control of the sugar beet nematode were begun. Close examination of sugar beet field plots where various volatile soil fumigants were tested indicated that several of the materials, including DDT reduced the nematode populations; but the high cost of such materials does not appear to justify field-scale applications in view of the limited increases in yield. Investigations in the greenhouse indicated that sugar beet seedlings growing in infested, treated and non-treated soils could be satisfactorily used as a measure of the relative efficiency of different soil fumigants.

Investigations of black root of sugar beets were intensified. In a series of tests involving the addition of chemicals to infested soils, it was found that the application of Arasan at the rate of 3 lb. per acre had no deleterious effect on germination of sugar beet seedlings, produced only slight toxicity effects, and greatly inhibited black root. At this concentration of the fungicide, the disease did not appear until the twenty-second day after planting. Preliminary tests of another recently developed protectant, copper trichlorophenate, applied at the rate of 2 lb. per acre, also gave encouraging results in the control of black root.

A study of the causal organisms of black root resulted in the consistent isolation of several fungi. Among them was a species of *Aphanomyces* isolated for the first time in Canada and recognized in other countries as a serious parasite of sugar beets.

Field investigations of soybean diseases were continued. In seed-treatment tests, Fermate, Arasan, and Spergon, gave higher emergence than Phygon or the controls. There was no significant difference between treatments with Fermate, Arasan and Spergon. Fermate gave yields slightly higher than Arasan and Spergon, whereas Phygon gave yields significantly lower than the checks.

Experiments were conducted to determine the effect of seed treatment on downy mildew (*Peronospora manshurica*) of soybean. Spergon reduced the amount of systemic infection from spore-encrusted seeds of the varieties Harman and A. K. Harrow.

In a study of progeny resulting from seed collected from soybean plants affected with bud blight, no evidence was obtained that this disease is seed-borne.

Because the valuable melon industry in southwestern Ontario is suffering serious losses from Fusarium wilt, a project was undertaken in co-operation with the Experimental Farms Service to develop new varieties resistant to the disease. Hybrids from crosses made in the field during the summer were tested in the greenhouse during the winter for their resistance to the wilt. Certain of the hybrids showed a measure of resistance.

Winnipeg, Man.

Cereal rusts caused only a small amount of damage in Manitoba in 1946. Damage due to wheat stem rust was negligible, but oat stem rust and leaf rust of wheat caused some yield reduction in late-sown crops.

The 1946 survey for physiologic races of leaf rust shows the common occurrence of strains capable of attacking Renown, Regent, and other wheats with similar leaf-rust reaction. Most of these strains are to be regarded as biotypes (sub-strains) of certain races common in former years. Such biotypes of races 5, 15, and 113 are particularly common as is also race 128, which is perhaps merely a virulent biotype of the formerly common race 29. Results of the current year's survey indicate that, in Manitoba and eastern Saskatchewan, the more virulent biotype of each of these races is now more common than the less virulent. In other parts of the country, these virulent strains are distinctly less abundant. Owing to the presence of these strains, Regent and other wheats of similar origin bore heavy leaf-rust infection in 1946 and escaped significant damage only because the crop had approached maturity before infection became heavy.

The presence of strains of leaf rust virulent towards the wheats now grown in the Prairie Provinces has necessitated a search for resistant varieties that might serve as suitable breeding material for the development of new wheats agronomically and otherwise suitable to this region. Tests carried out both in the greenhouse and in the field have demonstrated the existence of several wheats with satisfactory leaf-rust resistance and have, moreover, shown that considerable resistance to the newer leaf-rust strains is present in some of the wheats now being developed by the Dominion Laboratory of Cereal Breeding.

In stem rust of oats a similar situation prevails. The formerly rare physiologic race 8 has for several years increased in prevalence until in 1946 it constituted about 30 per cent of the oat stem rust present in Manitoba and Ontario. Owing to the ability of this race to rust the newer Canadian and American oat varieties, it is already a hazard to their production, although, in 1946, they suffered little damage because the late arrival and slow development of oat stem rust permitted the crop to mature before infection became heavy. In view of the now widespread occurrence of race 8, the production of Garry oats (in which this laboratory co-operated with the Dominion Laboratory of Cereal Breeding) is highly opportune. This variety possesses resistance not only to race 8 and all other known races of oat stem rust, but also to races of crown rust occurring in Canada. It is, furthermore, resistant to both of the smuts that attack oats.

A simple and rapid method has been developed for examining wheat heads for bunt infection. This method can be of value to both the farmer and the research worker. To the farmer it can be of service in the selection of wheat for seed purposes, and in determining whether or not the seed requires treatment with fungicides for bunt. To the research worker, it is of value because it permits head examination for the presence of bunt to be carried out with increased speed and accuracy.

Although the species of *Fusarium* associated with various diseases of crop plants in Canada are fairly well known, little information is available on their distribution in Canadian soils. For this reason, a preliminary microbiological study was made during 1946 of approximately 200 samples of soil obtained from various geographic areas in Canada. Results so far obtained from this study indicate that several of the species of *Fusarium* commonly associated with root rots, tuber rots, and other diseases of crop plants may be isolated directly from samples of soil from widely separated points in the country.

Results obtained from recent cultural studies with species of *Fusarium* commonly associated with diseases of cereals and other crop plants in Canada

indicate that more attention should be given to the cultures used for inoculation purposes in experimental pathogenicity tests. Studies with cultures of single-spore origin indicate that spontaneous changes may lead to the production of genetically distinct mycelia. This phenomenon, occurring as it does in single-spore cultures, appears to offer an explanation for the inconsistent results that sometimes arise in pathogenic tests.

Twenty-seven varieties of common wheat, 41 varieties of barley, and 46 varieties of oats were tested in 1946 at 6 stations in Manitoba for resistance to common root-rot (*Helminthosporium* spp. and *Fusarium* spp.). In each crop group, several new varieties proved to be very resistant to this widespread disease. Among the older varieties, there were indications that varieties of relatively wide zonal adaptability were more resistant than varieties of narrow adaptability.

Studies on the relation of seed infection by *Helminthosporium sativum* to the subsequent yield of Regent wheat and Nobarb barley failed to show that severe infection of the seed resulted in reduced yield despite the fact that germination of the seed was lowered by the infection.

Comparisons of various proprietary seed disinfectants applied to wheat and barley seed severely infected with the fungus *Helminthosporium sativum* showed that nearly all of them increased seed germination and reduced the severity of blighting in the seedlings. Increases in yield, as the result of seed disinfection were, however, relatively small or absent.

A new method of inoculation for initiating infection with bacterial black chaff in field plots was found effective in a yield test of 98 wheat varieties. A detailed statistical analysis of the data demonstrated that a sound basis existed for the selection of varieties resistant to bacterial black chaff from among plots inoculated by this method.

Studies on control measures for grey speck of oats, caused by deficiency of manganese in the soil, showed that steeping the seed in a solution of manganese sulphate prior to seeding gave reasonably effective control. Marked differences were observed in varietal susceptibility to grey speck, high susceptibility being characteristic of most but not all varieties descended from crosses with the crown-rust-resistant variety Victoria.

Co-operative trials on seed disinfection of flax were carried out at 21 different stations, 8 in the United States and 13 in Canada. The over-all results showed that uninjured flax seed germinated much better and gave somewhat higher yields than did fractured seed. The field data showed, also, that New Improved Ceresan, applied at the rate of two ounces per bushel gave the best results with respect to both germination and yield. Applied at lower rates, this disinfectant proved to be correspondingly less beneficial. Other seed disinfectants, such as Spergon and Arasan, were somewhat less effective than New Improved Ceresan. The benefit from seed treatment, with all the disinfectants tried, was less with uninjured than with injured seed.

Among diseases of crops other than cereals several are worthy of mention. Pasmo disease of flax was more prevalent in 1946 than in the previous year and was for the first time shown to extend beyond the western boundary of Manitoba. Wilt of sunflowers caused considerable losses among growers of sunflower seed for oil extraction. A survey of alfalfa fields indicates that Rhizoctonia crown rot has increased in prevalence and has now become the most important disease of that crop in Manitoba. The survey also showed that bacterial wilt of alfalfa, first found in Manitoba in 1945, was present in widely separated localities of the province in 1946. Owing to the great increase that has taken place in recent years in the acreage devoted to alfalfa, these diseases cannot be regarded as of

Bacterial blight of peas is also of current interest because of the recent large increase in the acreage devoted to field peas in Manitoba. Surveys minor importance.

indicated that in 1946 nearly 50 per cent of the fields in the most important pea-growing area of the province were infected, some of them severely.

Saskatoon, Sask.

Survey trips were made through most of the crop districts, and particular attention was given to the incidence and economic importance of root diseases. Take-all (*Ophiobolus graminis*) and browning root-rot (*Pythium* spp.), both serious diseases of wheat in former years, were of minor importance this season. Common root-rot (*Helminthosporium sativum* and *Fusarium* spp.), however, was prevalent on all cereal crops. In 226 wheat fields examined, varying degrees of infection were found. An increase in incidence over 1945 was evident in crop districts Nos. 3 and 4, the heavy infections being probably related to the occurrence of successive dry years in these districts. A notable feature of the infections in 1946, in several districts, was the degree of infection of the culms above ground level.

Leaf rust of wheat (*Puccinia triticina*) was severe in the eastern parts of the province. Other rusts were of minor importance.

Bacterial wilt (*Corynebacterium insidiosum*) of alfalfa was a serious limiting factor in the production of this crop in the irrigated areas of the southwest. Winter crown rot (low-temperature basidiomycete) and black stem (*Ascochyta imperfecta*) were severe in some fields in the northern alfalfa areas. Pea diseases such as the seed-borne blight (*Mycosphaerella pinodes*) and leaf and pod-spot (*Ascochyta Pisi*) were found to be serious and threatening the field pea seed industry in the northeast. The increasing spread of ring rot (*Corynebacterium sepedonicum*) is causing anxiety, especially among growers of certified seed potatoes.

For several years, investigations have been conducted on the recovery of wheat and barley from injury caused by *Helminthosporium sativum*, a common root-rot pathogen. Recently, some recovery experiments were completed with *Pythium arrhenomanes*, a root parasite. Injuries through root infections could then be compared, in respect to recovery, with injuries to the lower portion of the stem as caused by invasions of *H. sativum*. A greenhouse experiment was set up with 16 treatment combinations. The variables were the presence or absence of *P. arrehenomanes*, the concentrations of phosphate and nitrate, and the soil moisture content. The presence of the pathogen reduced the area of the first two leaves by 40 per cent, of the third leaf by 24 per cent, of the fourth and the fifth by 38 per cent, and of the sixth to the ninth by amounts diminishing to 7 per cent. The yield of the diseased plants was 93 per cent of the controls. Phosphate and high soil moisture favoured recovery from the disease, as indicated by leaf area and yield.

Investigations on resistance of cereal varieties and lines to root-rot pathogens, mainly *Helminthosporium sativum*, were continued. Many Thatcher and Reward lines were tested. The former variety showed evidence of heterogeneity for resistance to *H. sativum* and selection of lines for this character may be possible. Heterogeneity was not evident in the Reward lines. A group of Kenya wheat lines from crosses with Marquis and with Rival were compared with parental material and also with Thatcher and Reward. The results, on an infection rating basis with 100 per cent maximum, were as follows: K9 with a rating of 19; K8, 40; K12, 41; K11, 40; K10. 59; Rival, 77; Marquis, 83; Thatcher, 81; and Reward, 92. Additional tests with the K9 line indicated a fair degree of resistance in comparison with Marquis. The rating for K9 was 42·5 and for Marquis, 80. In a greenhouse test, for another purpose, an outbreak of severe common root-rot occurred thus presenting an opportunity for comparative resistance readings. Thatcher, Apex and Pelissier were found to be quite resistant and Regent, Red Bobs, Marquis, Red Fife, Reliance, Mindum and Carleton quite susceptible.

Further studies on the occurrence of *Helminthosporium sativum* in nature brought to light apparent antibiotic factors, which have received some attention. A wide variety of bacteria occurs on the surface of wheat straw and other plant parts. Many of these organisms have been found to be antagonistic to *H. sativum*.

Further tests were conducted on the relation between spore load and subsequent infection in the field with the bunt of wheat and the covered smuts of oats and barley. The seed for these tests was secured from two commercial seed-testing laboratories at Saskatoon and Winnipeg. Also co-operative tests were made in Manitoba, Saskatchewan, and Alberta to obtain additional information on the reliability of seed examination to determine the need for seed treatment. Samples of wheat, oats, and barley were obtained showing spore-loads as follows: clean, trace, slight, and moderate to heavy. Replicated plots were sown and the amount of smut was recorded at harvest time. The results confirmed previous work and indicate the reliability of the seed examination procedure. There was a fairly consistent increase in infection with each increase in spore-load.

Greenhouse and field experiments were conducted to determine the resistance of recommended varieties of wheat, oats, and barley to the above-mentioned smuts. Composite inocula from various parts of Saskatchewan, which presumably contained most of the physiologic races present in the province, were used for each smut. In the wheat experiments, infections ranged from 65 to 87 per cent under greenhouse conditions and from 11 to 75 per cent in the field. In both tests, Regent was the least susceptible and Red Bobs the most susceptible, Apex, Reliance, and Thatcher being intermediate. In the oat variety experiment, Brighton and Valor were very resistant and Exeter and Victory very susceptible. Ajax held an intermediate position. Of the barley varieties, Titan appeared to be immune, Newal and O.A.C. 21 were very resistant; Hannchen, Montcalm, and Prospect, moderately resistant; and Regal, Rex, and Warrior, slightly resistant.

A field experiment to compare different fungicides and methods of treatment for the control of surface-borne smuts was completed. All treatments, except formalin, controlled bunt of wheat perfectly. Ceresan dust at the standard rate, Ceresan dip and Du Bay No. 1452F controlled the covered smuts of both barley and oats. Ceresan dust at ¾ the normal rate gave almost perfect control of the covered smuts of oats and barley. U.S. Rubber Co. fungicide No. 604 controlled covered smut of barley. On the other hand, Leytosan and No. 604 failed to control oat smut satisfactorily; Leytosan and formalin were also unsatisfactory for covered and for false loose smut of barley. Formalin caused reductions in yield in all three cereals.

Work was conducted towards improvement of the hot water treatment for the control of true loose smut (*Ustilago nuda*) of barley. In several greenhouse and field tests, satisfactory control was obtained with the following procedure: the seed was (1) presoaked in cold water for 1 hour; (2) removed from the water but kept wet for 4 hours; (3) placed in water at 125° F. for 11 minutes; (4) removed and cooled immediately in cold water; and (5) spread out to dry for 5 days. With this procedure, there was less reduction in emergence than with the usual method employing 128° F.

A co-operative experiment with the Winnipeg and Edmonton laboratories was conducted to determine the influence of different amounts of disease in seed samples. Samples of Regent wheat and Nobarb barley were employed. The samples in each case contained 0, 25, 50 and 100 per cent of kernels infected with *Helminthosporium sativum*, a pathogen causing seedling blight and common root-rot. The diseased kernels did not reduce the yield significantly in any lot. Emergence, however, was noticeably reduced at some stations in the more heavily infected lots.

Greenhouse and field tests were conducted to determine the relationship of moisture content of sound and injured wheat seed to seed treatment with mercury dusts. The effect of seed treatment generally was to improve germination, particularly that of injured seed. With Ceresan dust, the improvement was reduced in the moister samples due to mercury poisoning. Leytosan dust, however, caused very little poisoning.

In amputation experiments in 1946, using Ajax and Banner oats, root and shoot amputations were carried out on different dates. Seminal root amputations did not affect the date of maturity but reduced the yield about 15 per cent. Shoot amputations reduced the yield 8·4 per cent. In a root amputation experiment in the early seedling stage on Marquis wheat, the removal of the primary root reduced the yield by 10 per cent, and of one first lateral by 9 per cent. These reductions are smaller than when the same roots are removed later in the growth period.

Further trials were made of the effect of seed treatment and dates of seeding on emergence and yield of field peas. Seed of the variety Dashaway treated with Ceresan or Arasan at one ounce per bushel was sown at Codette and Saskatoon on two different dates. At both places, Ceresan gave a marked increase and Arasan a slight increase in emergence. Emergence in the late-sown plots was decidedly better than the early sown, but this difference was much less where the seed was treated. Seed lots with up to 20 per cent infection with *Mycosphaerella pinodes* emerged approximately as well as healthy seed.

Edmonton, Alta.

In co-operation with the Dominion Experimental Station, Lethbridge, surveys were made of winter wheat fields from the seedling stage to maturity, with special attention to effect of crop sequence and other cultural factors on the development of root-rots. Take-all caused heavy loss in many fields and common root-rot was prevalent. In field tests, several varieties of wheat are continuing to show considerable resistance to the root-rotting fungi.

Studies on bacterial wilt and winter crown rot of alfalfa were continued. Special emphasis is being given to the search for disease-resistant varieties in the control of the various diseases of the forage crops. In this connection extensive co-operative work is in progress with the Experimental Farms Service at Saskatoon and Lethbridge.

Besides examining for the presence of bacterial ring rot many samples of potatoes sent to the laboratory, a member of the staff assisted the Alberta Department of Agriculture for approximately a month in its annual field survey, and made the official laboratory diagnosis of suspected samples from several hundred fields. Investigations of the nature and spread of stem-end discoloration and phloem necrosis of potato tubers were continued. The severity of the Rhizoctonia disease of potato has been found to be materially reduced by the application to the soil of various nitrogenous salts. Various chemical treatments of cut potato sets to control rotting by soil-borne fungi were tested. Certain treatments appeared promising. Studies on the nature and cause of purple top of potatoes were continued.

Summerland, B.C.

Investigations on crown rot of apples in 1946 included experiments on the control of the disease by chemicals and by a bacterial antibiotic, in addition to the varietal trials.

Fermate was tested for the control of apple scab for the fifth year. When combined with lime sulphur or a wettable sulphur, it has proved to be effective against this disease under local conditions.

Four fungicides, bordeaux, Perenox, Fermate, and Phygon, were tested for the control of Coryneum spot of apricot. All were effective, but 1946 was not a good test year, as Coryneum spot was not severe even in the check plots.

In the Kootenay Valley, the virus disease "little cherry" became more serious in districts where it was already known, and made its appearance in several new districts. In the Kootenay Bay experimental orchard of 60 trees, where 16 trees were inoculated in 1943, the disease spread till it included all but two trees in 1946. Varietal resistance trials and alternate host studies were initiated this year. Detailed observations were made on symptom expression. In the Okanagan Valley, a single tree suspected of "little cherry" was found and removed.

In mapped orchards of Western X-disease of peach in the Okanagan, increase of infection was 0·4 per cent, slightly less than that of last year. This is the first time in eight years that the number of new infections has not shown a small increase over that of the preceding year.

A disease of cherry, possibly a form of Lambert mottle, but spreading faster both within the individual tree and from tree to tree, has appeared in the Kelowna district.

A non-transmissible abnormality of Bing cherries. which could be confused with "little cherry", was described and given the name "small bitter cherry".

In studies on *Alternaria radicina*, the cause of black rot of carrot, it was shown that this fungus produced no rot when inoculated into beet, mangel, parsnip, potato, onion or radish. Mature carrots could be infected without wounding; carrot seedlings could be infected through both tops and roots; and, with an optimum supply of nitrogen in nutrient culture, the presence of boron retarded black rot development. The most effective control of *Alternaria Raphani* on radish seed was again obtained by soaking the seed in water at 50 degrees C. for 10 to 40 minutes. The best chemical control was obtained with Semesan Jr., and Puratized N5-E.

Vancouver, B.C.

In order to provide more adequate plant pathological assistance to growers of various agricultural crops in the Coastal region of British Columbia, a new laboratory was organized in 1946 at Vancouver. This laboratory occupies temporary quarters in a part of a converted army hut, which is located on the campus of the University of British Columbia. The scientific staff consists of an Officer-in-Charge and two assistants. Exploratory work on disease problems within the area is under way with a view to the development of a sound program of research.

Saanichton, B.C.

The bulb advisory and inspection service covered 355 plantings, comprising approximately 34 million bulbs, an increase of approximately 2½ million over the previous season.

Diseases of Bulbs.—Immersion of tulip bulbs for one hour at 110-112 degrees Fahrenheit in 1 per cent and 2 per cent formalin solutions for the control of tulip fire markedly reduced flower production, but did not reduce significantly the growth of the bulbs.

Experiments to control basal rot in King Alfred daffodils by dusting infected bulbs with Spergon, Arasan, and Fermate were found to delay expression of symptoms, but the fungicides failed to prevent the almost complete destruction of the bulbs when they were planted in a greenhouse under normal conditions for forcing. Under field conditions, the causal organism was less destructive to the bulbs, but, again, the dusts failed to check its progress. The immersion of the bulbs for one hour in a cold Ceresan solution (0·3 per cent), and in a

warm formalin solution (0·5 per cent at 110-112°F.) were the only treatments that reduced the amount of infection below that in the control plots. When healthy bulbs were planted in infested soil, dusting with Spergon, Fermate, Dow Dust No. 5, and Arasan delayed but failed to prevent infection. Dusting with Ceresan proved superior to all other treatments, and this fungicide was more effective as a dust than a dip.

In the control of rots, caused by *Penicillium* species, which occur in the propagation of hyacinth, dusting with Spergon, Arasan, and Nomersan was effective. These dusts increased the yield of bulblets. A further increase in bulblet yield was obtained by adding a trace of naphthaleneacetic acid to the Arasan dust. Dusting with Spergon, Dow Dust No. 5, Arasan and Nomersan was effective in preventing the development of the *Penicillium* storage rot of tulip and iris bulbs. Fermate, Dithane, two proprietary sulphur dusts, a proprietary bordeaux dust, and yellow cuprous oxide exerted little or no protective effect.

Immersion of healthy and virus-infected iris bulbs for periods of 24 hours or less in a 1 per cent solution of urea induced longer stems, and earlier and more abundant bloom when the bulbs were forced under glass. The treatment failed to reduce the amount of virus infection.

A study of the symptoms induced by the bulb nematode in iris has shown that in harvested bulbs a grey-green discoloration flecked with white specks is the most consistent diagnostic symptom. To detect this symptom, the residual basal cap must be removed. In growing crops, a grey-green discoloration at the point where the stem is attached to the bulb is also a useful and reliable symptom. Iris varieties vary in susceptibility; 19 have been classified tentatively as follows: *Highly susceptible:* Supreme, White Excelsior, Bloemaard, Thunderbolt, and King of the Blues; *Susceptible:* Hart Nibbrig, Van Everdingen, Cornelia, and Prince Albert; *Slightly resistant:* Wedgewood, Yellow Queen, Poggenbeek, Imperator, Queen Wilhelmina, Cajanus, Count of Nassau, and Louis; and *Resistant:* La Renaissance, and King of the Whites.

A study was made to determine the effect of adding various fungicides to the water in which iris bulbs infected with nematodes were immersed for one hour at 110-112°F. At harvest, no infection was found in lots treated with formalin (0·5 per cent) or yellow cuprous oxide (0·5 per cent). When Arasan (0·5 per cent), Fermate (0·5 per cent), Semesan (0·25 per cent), and Ceresan (0·25 per cent) were added, the harvested bulbs carried 8 to 14 per cent infection as compared with 20 per cent infection in the control bulbs.

Other Diseases.—Plantings of the raspberry varieties Washington, Taylor, and Sunrise, were inspected and certified for the first time in British Columbia.

During 1946, 39 unreported plant diseases were added to the "Check List of Plant Diseases of the Coastal Areas of British Columbia." The two most important ones were stem rust of orchard grass and common leaf spot (*Pseudopeziza Trifolii*) on Ladino white clover. A total of 308 plant disease specimens including 125 on potatoes, were sent to the Laboratory for diagnosis. In addition, 168 other specimens were collected, and, of these, 126 were identified and added to the herbarium.

From January 1 to March 31, 1946, samples from 86 cars of commercial potatoes imported from United States points were examined for the presence of bacterial ring rot; of these, 75 samples were positive. The disease was also found in one sample from a commercial field at Courtenay, Vancouver Island. This is the only record of the disease on potatoes grown in British Columbia in 1946.

Late blight infection of tubers was materially reduced where the potato foliage was killed by herbicides. Seed potato tubers showing vascular discoloration due to killing of foliage with herbicides were tested for germination.

The results showed that germination was not adversely affected. When freshly cut potato sets were dusted with Fermate, premature rotting by *Pythium ultima* was effectively prevented. Experiments have shown that the current practice of dusting sets with hydrated lime or sulphur was not effective. Accordingly, Fermate is now recommended for the control of *Pythium* rot, and also to prevent sets from sticking together in the planter.

Twenty-nine Foundation vegetable seed crops were inspected. The worst seed-borne disease found was grey mould on the pods of Masterpiece beans at Agassiz, B.C. Other diseases that caused moderate to severe crop damage were black root-rot of spinach, drop and downy mildew of lettuce, and root-rot of peas.

Victoria, B.C. (*Forest Pathology*)

The study of decays attacking Sitka spruce on the Queen Charlotte Islands in relation to the management of the species has been completed. Based on a detailed analysis of 1,977 trees, the information gathered has been published in one technical bulletin, one technical paper, and four semi-technical articles.

To complete pathological investigations of the species of major economic importance on the Queen Charlotte Islands, a study similar to that completed for Sitka spruce was carried out for western hemlock in the region. The investigation was undertaken in 1945 and expanded in 1946 to include information relating to the management and utilization of this important species. Detailed information has been obtained on over 1,700 trees in the four major areas of production and a preliminary report on the decay situation has been prepared for consideration by the forest industry.

In answer to requests from pathologists in England relative to the significance of heartwood discolorations of western red cedar, an article has been published after an intensive study of the decays of cedar. No further work is contemplated in the near future on decay in relation to the management of this species. Several requests have been received, however, for a pathological investigation of immature cedar. This work will be undertaken as soon as studies of more immediate importance are completed.

The investigation of decay in balsam fir in the spruce-balsam forest type in the upper Fraser region of British Columbia has been completed, and the information will shortly be published in a bulletin. In the past, the cutting of balsam has been made optional in a majority of the timber sale contracts awarded by the Government, as the mature and overmature balsam was thought to be subject to considerable defect. The investigation indicated that a considerable amount of sound wood suitable for sawlogs or pulp was being left after logging. In an analysis of 1,748 trees on 25 acres, it was found that a net merchantable volume of 3,164 board feet or 10·2 cords per acre remained.

The investigation initiated in 1945 in co-operation with a local timber firm, to study the relation of decay to the management of the hemlock-balsam forests on the west coast of Vancouver Island was continued in 1946. More data will be required, but it is expected that the study will be completed early in 1947. To date, 1,682 hemlock and balsam trees have been analysed in detail on 20·4 acres. Decay and other losses in relation to diameter, age, and site have been computed to establish a basis for determining priority of cutting for the present mature and overmature stands on the area, covering some 500,000 acres.

A preliminary study of decay entering basal scars in 70-year-old western white pine at Revelstoke, B.C., was conducted in 1944. Following experimental cuttings made in co-operation with the British Columbia Forest Service in 1946, the study was completed. It was observed that the basal scars, made by porcupines 30 to 40 years ago, were infected by two virulent wood-destroying organisms, *Stereum sanguinolentum* and *Fomes Pini*. The detailed analysis

of infected stems indicated that at the end of the present rotation, or when the trees were 120 years of age, 49·5 per cent of the cubic volume of infected trees, or the equivalent of 5 linear feet more than the butt 16-foot log, will have been destroyed. Recommendations were made for the management of the scarred stands, covering some 500 acres.

In co-operation with the British Columbia Forest Service, a preliminary survey of the extent of white pine blister rust (*Cronartium ribicola*) in the Upper Arrow Lake and Slocan Lake watersheds was conducted in 1946. The investigation will be continued in an endeavour to control the blister rust by careful management of white pine stands. The species is second only to Douglas fir in economic importance in the region. The results of the survey to date indicate that in the stands investigated, from 38 to 69 years of age, 48 per cent of the trees in the most disease-free stands to 93 per cent in the most heavily diseased stands are infected by blister rust.

Remeasurements were made on the sample plots established for the study of the spread of *Poria Weirii* root-rot in Douglas fir at Cowichan Lake, B.C. The loss of increment in cubic measure was computed. It was found that the disease interferes seriously with the stocking of naturally regenerated stands.

Following numerous requests to ascertain the cause of dead tops in young western larch in the Arrow Lakes region, a brief survey was made of the conditions. It was found that rodents had stripped the bark off from 8 inches to 3 feet, 4 to 12 or more feet from the top. The trees were 25 to 30 years old, 35 to 45 feet in height.

An investigation into the cause of death of a large number of Douglas fir seedlings at the new Duncan nursery of the British Columbia Forest Service revealed that 16·8 per cent of the 10,650 seedlings inspected were infected by late top-infection damping-off, caused by *Fusarium oxysporum* form *Pini*. Extensive experiments to prevent a similar outbreak of disease will be conducted in the spring of 1947.

DIVISION OF CHEMISTRY

Animal Nutrition

As forecast in the report of the previous year new methods are being developed for the determination of the nutritive value of Canadian livestock feeds. These methods deal with the utilization of feed protein by cattle and swine and with the use of stable isotopes of carbon, hydrogen, and nitrogen to trace the course of the metabolism of feed stuffs. At the same time the original basic work of the Unit on the digestibility of Canadian feed stuffs for cattle, sheep, and swine has been continued.

These studies were inaugurated with three purposes in view: (1) to determine the optimum conditions for carrying out digestibility trials; (2) to determine whether such coefficients of digestibility could be used as criteria for evaluating Canadian feed stuffs; and (3) to make a survey of the feeding value of Canadian feed stuffs, both commercial and home-grown, on the basis of their content of digestible nutrients. The studies on the conditions under which digestibility trials were carried out are nearing conclusion. Two major experiments were conducted during 1946. Results of these greatly added to the knowledge obtained in the work of previous years. It is expected that the series of experiments in regard to factors affecting digestibility will be concluded in 1947. Results of the 17 years' work, reported periodically in scientific papers, will be published in bulletin form.

Using a technique developed in this laboratory, a systematic examination is being made of Canadian feed stuffs for cattle, sheep, and swine. During the

past year this survey has covered a number of swine feeds, such as home-grown grains, milling by-products, and packing-house by-products. With sheep it has covered the study of the evaluation of different methods of conserving herbage. With cattle it has included studies on certain vegetable protein concentrates.

Considerable attention is being given to the relative values of feed proteins from different sources. It has been established that for animals other than ruminants there are certain amino acids which must be present in the feed proteins in order that those proteins may have their full value. With ruminants there is doubt that this holds true. One phase of the work in this unit is devoted to a study of whether or not in the case of cattle there are certain indispensable and essential amino acids which should be present in the feed protein. In other words, can cattle make use of any nitrogen from any organic source whatsoever to satisfy their requirements? This study has been undertaken by a new technique developed by the Division of Chemistry for the determination of the biological values of feed proteins with cattle.

During the past year these protein studies have been extended to swine. Here again, a new technique has been developed and its reliability is being tested. It is anticipated, with this new technique, that it will be possible to determine the biological values of proteins for growing and fattening swine under the conditions which would exist in practical husbandry.

Progress has been made in the development of a technique for the use of stable isotopes of hydrogen, nitrogen, and carbon to study the metabolism and utilization of feed stuffs by farm animals. The necessary apparatus has been assembled and the preliminary experiments carried out.

Progress has also been made in the development of a technique for the determination of the actual consumption of total digestible nutrients by sheep on pasture. The principle of this method is based upon a combination of laboratory metabolism trials and field grazing conditions. The fresh pasture is examined from a nutritive standpoint in the laboratory and at the same time by means of proper equipment the actual consumption is recorded in the field. It is expected that the incorporation of this service in the pasture investigations of the Experimental Farms Service will greatly enhance the value of the results of their investigations.

Food Investigations

The main function of the food investigation unit has been investigation and control work for various divisions of the Department to maintain standards of quality for processed foods. Service for the Health of Animals Division of Production Service has included the examination of over 1,400 samples of packing-house products and imported gelatines for purity and conformity to standards. For the Fruit and Vegetable Division of Marketing Service 595 samples of processed fruit and vegetable and maple products were examined under the regulations of the Meat and Canned Foods and the Maple Industry Acts. Service to the Dairy Products Division has increased considerably. With new regulations in connection with the grading and marketing of milk powders, approximately 3,000 samples of milk powders and 600 samples of cheese and other milk products were analysed.

As a result of consultations between the Meat Board and exporting packing houses, trial shipments were made to Great Britain of milder cured Wiltshire sides. This Division co-operated in making chemical and physical analyses of the cured sides and of the pump and cure pickles taken at 36 packing houses throughout Canada. Under proper control in accordance with prescribed specifications the milder cures were found to be quite satisfactory. This survey has provided useful data for correlating bacon quality with composition of curing

pickle and will be of considerable value in future control work. The laboratory has also co-operated with the Meat Board in checking on export shipments of horse meat to Europe.

The laboratory has continued to co-operate with the Special Products Board in the examination for conformity to specifications of all export shipments of dried egg powders to the United Kingdom under agreement with the British Ministry of Food. This year all samples were sugar dried eggs for the baking trade, which must contain 33 per cent sugar in the dry powder. The laboratory has also co-operated with the industry in examining check samples taken at the various plants with the object of increasing the efficiency of plant operation. This service has helped to maintain the high reputation which Canadian dried egg powders have established.

Studies of the effect of canning procedures on vitamin C content of tomatoes have been carried out in co-operation with the Consumer Section, Marketing Service.

Problems in dairy science were studied in co-operation with the Division of Bacteriology and Dairy Research. The relation of lactic acid development and fat acidity determination to lipolytic flavour defects in cheddar cheese, calcium content of fluid milk, and brown discoloration in malted process cheese are topics which have been reported previously but which were brought to completion during the past year. A method has been developed for making sediment tests on composite samples of milk. By this procedure it is now possible to obtain an average sediment test for successive 15-day periods for each milk patron. A new method of determining setting time in cheddar cheese making, called the pink test, has been developed. This test measures the rate of lactic acid production in cheese milk rather than its quantity and is a more reliable indication of when the cheese milk has been sufficiently ripened for the addition of rennet. Both these developments should, in time, contribute to a higher quality in Canadian cheddar cheese.

Horticultural Chemistry

The main study of the past year has been the effects on vitamin retention, particularly of vitamin C, of freezing preservation of fruits and vegetables. The effects of different methods of preparation, packing, freezing, and storage have been examined. The examination of the stored materials still continues. The results will be used in conjunction with quality evaluations by the Division of Horticulture to choose the best methods of freezing preservation. In the course of the work 650 samples of fresh and frozen fruits and 700 samples of fresh and frozen vegetables have been examined for vitamin C content. Duplicate cartons were examined at each sampling date. The vegetables were analysed after cooking in a large number of cases.

A number of different fruit juices were prepared by the Horticultural Division by different processes. The effects of these processes and subsequent storage on vitamin C content and acidity were followed, and some 150 samples were analysed. Vitamin C fortified apple juices were examined to the number of 180 and almost all found to contain the required amount.

The specific gravities of 100 tomato juices were determined before and after filtration in order to see if specific gravity might be used in evaluating quality. The inspection at the plant would of necessity be made on the filtered sample, as the determination on the unfiltered juice requires very expensive equipment. There was not a sufficiently consistent relationship between the two specific gravities to allow of this simplified procedure being used. In any case, the specific gravity was not closely associated with quality.

The work on selection of tomato varieties of high vitamin C content was continued. Probably because of more uniform weather conditions successive examinations of the same variety agreed more closely this year and significant differences between varieties were evident. At least one more season's work is necessary before authoritative statements may be made. Varieties high in vitamin C may be suitable for commercial use or for crossing to obtain more desirable varieties.

About 350 different varieties of apples were analysed for vitamin C content with a view to popularizing those of high content, or, if low in quality, of using them to develop better varieties. Nineteen varieties had a content of higher than 15 milligrams for 100 grams, which is roughly half that of oranges.

A few plants were still manufacturing dehydrated vegetables and some 100 odd samples were examined for moisture and sulphur dioxide contents.

The Division of Horticulture has a very active program of plant tissue mineral tests as a guide to fertilizer requirements. In collaboration with them a number of methods of analysis for each of several universal elements were tried out. A set of methods has been evolved, with some modifications made here, which yield data by very rapid methods that compare favourably with data obtained by the much more laborious quantitative methods.

Plant Chemistry

The use of new and improved insecticide materials has required investigation into suitable methods for the detection of spray residues on farm products. Arsenic, lead, DDT, and hexachlorocyclohexane were determined in various crops, and in one case on bees, to assist in the development of spray programs which will be adequate to control pests but will not leave a harmful amount of residue.

Long-term projects in co-operation with other Divisions of the Department have been continued. About 1,500 samples of wheat were tested for moisture and protein to assist the Cereal Division in the development of new and improved varieties of wheat with good milling and baking properties. Considerable work was also done in co-operation with the Division of Forage Plants which is conducting a series of experiments with grass—legume mixtures in short-term rotation. The crops were cut twice during the season to simulate hay, or five times to simulate pasture conditions. Analysis of the crops will indicate the best treatment to obtain a high amount of protein during the three-year rotation. Analytical work in connection with hay curing trials of the Field Husbandry Division showed that barn curing retained the protein, mineral, and carotene of the fresh crop better than field curing.

Investigation into the effect of storage on the carotene content of carrots has been continued. Although there is some variation, the carotene content remains high during good storage conditions. Carrots should make a good supplementary source of carotene for animal feeding during the winter months when other sources are scarce.

Work on a suitable method for determining cobalt in plant materials has been completed. A perchloric acid digestion followed by colour development with nitroso-R-salt in the presence of a buffer was found most satisfactory. It will now be possible to make a survey of Canadian crops to determine the location and extent of cobalt-deficient areas.

A rapid method for determining the iodine number of oils from oil-bearing seeds was investigated and adapted for use in the laboratory. This considerably shortens the time required for analysis of western flaxseed and soybeans, and enables the completion of the work in time for reporting at winter conferences.

Analytical services for other units of the Division involved over 5,000 samples analysed for feed constituents, calcuim, phosphorus or other minerals. As a service to the public, 153 samples of feeding stuff were analysed.

Soils and Fertilizers

Investigations on the composition of the colloidal fractions of soils have been carried out for several years and a number of papers on the subject have been published. In studying the effect of various field treatments on the soil colloids, one of the difficulties encountered was the natural variation of soil in the field. It became obvious that, in order to attain the objective, it would be necessary to begin with a large uniform quantity of soil and apply treatments in the laboratory under controlled conditions. Consequently, such an experiment was begun during the past year, using a soil from the brown soil zone in Saskatchewan and one from the podzol zone in Quebec. These samples are similar in their total chemical composition in that their total content of C, N and P is approximately the same but they are quite different in their colloid content and crop-producing power (Soil Sc. *57*, 233-240, 1944). The experiment is so designed that different lots can be treated frequently with lime, manure and superphosphate (each singly as well as in combination) and, after a considerable amount of these materials has been added, the crop-producing power as well as the colloidal content and other chemical properties can be thoroughly studied. It is hoped that this experiment will contribute considerably to the knowledge of the effects of these common treatments on soil composition and fertility.

A fairly comprehensive study of the use of rapid soil tests, as well as of laboratory methods, for determining available plant food constituents was completed. It was generally concluded that the present methods available are inadequate and the results pointed to the need of a continued program of research in soil chemistry so that present methods of measuring soil fertility can be improved and new methods developed. There are many difficulties encountered in field studies of this nature and it is believed that greenhouse studies would eliminate a considerable number of these. Consequently an investigation has recently been undertaken, in co-operation with the Division of Field Husbandry, including a combined laboratory and greenhouse study of 30 soils, representing 10 of the major soil types of Carleton county, Ont., with a view to correlating laboratory methods with fertilizer response.

A study of plant tissue tests was carried out on three crops treated with eight different fertilizer treatments each replicated four times, the experiment being laid out on two different areas. The concentration of nitrates, phosphates and potassium was determined on sodium acetate extracts of the leaves of corn and oats and the stems of potatoes. Increased rates of application of an element in the fertilizer in most cases brought about significant increases in the concentration of that element in the plant. Since the yields were not significantly increased by fertilizer treatments, it was not possible to correlate plant tissue test results with crop yields.

A method of "foliar diagnosis" used by workers in Pennsylvania to determine nutrient requirements of plants was investigated. Leaf samples from corn, oats, and tomato plants grown on fertility plots under different fertilizer treatments were analysed for nitrogen, phosphorus, potassium, calcium, and magnesium. It was concluded from a study of the results that the method was not generally applicable, though it might be useful in special cases.

A program of research into soil organic matter was begun in 1945. In that year plots were established on a light sandy soil and annual applications of different kinds of organic matter will be made. In 1946, a similar series of plots

was established on a clay soil. The purpose of the experiment is to determine the long-time effect of adding different kinds of organic matter (manure, muck, peat, green rye, alfalfa, straw, and leaves) on the chemical composition and physical properties of the soil. In the laboratory, preliminary studies of the chemistry of the nitrogen compounds in soil organic matter have been made. One of the most important problems here is the separation of the organic matter from the very much larger mineral fraction, and several methods of doing this have been examined. An oxidation method using sodium paraperiodate has also been investigated. To date, these studies have been of an exploratory nature only.

In research on soil phosphorus, a study was made of a proposed method for determining adsorbed phosphates as a measure of that fraction which is more or less readily available to plants. This has led to an investigation of the part played by the hydrated oxides of iron and aluminum in adsorbing phosphates and of the release of this adsorbed phosphate by the fluoride ion. A review of the literature has indicated that little has been done on a study of this fundamental problem and the work on it is being followed with interest. The use of 8-hydroxyquinoline or "oxine" in preventing the reprecipitation of phosphate by iron and aluminum in acid soil extracts is also being studied.

Soil samples were collected from the plots of the soil erosion experiment conducted by the Division of Field Husbandry and a number of physical determinations were made, including mechanical analysis, moisture equivalent, and colloids by water vapour absorption. It was found that the soil was highly erodible according to the criteria used by workers in this field in the United States. It was also shown that there was a large variation in the mechanical composition of the soil within individual plots. Some work is being done on the eroded material from these plots.

A greenhouse experiment was conducted to determine the fertilizing value of an ammoniated waste sulphite liquor product supplied by the International Paper Company at Hawkesbury, Ont. This material contained 3·7 per cent nitrogen and 1·20 per cent ash. Results indicated that the product was a highly satisfactory source of nitrogen for oats grown in the greenhouse, when compared with manure and commercial fertilizers. An experiment using pots sunk in the ground outdoors was carried out with a second sample of the material but gave inconclusive results. A third sample is being tested in the greenhouse but is not giving the same apparent good results as the first sample. Chemical tests have indicated that the nitrogen in the third sample is probably not so readily available as that in the first sample.

A co-operative experiment with the Division of Horticulture was undertaken at the Horticulture Substation at Smithfield, Ont. Its purpose is to determine the best crop rotation and soil treatment to produce the maximum number of canning crops while maintaining soil productivity. A suitable area was selected and carefully sampled, and the samples were analysed in the laboratory. Soil conditions will be examined periodically by this Division. A number of other soil samples were also collected and examined to determine soil conditions in the various parts of the Substation area.

In connection with a soil survey of areas in the Northwest Territories, 85 soil samples were analysed and reported to the official in charge. A further set of 27 samples from the same area has recently been received. In addition, 28 profile samples collected in the soil survey of Prince Edward Island were analysed for total nitrogen and exchangeable bases.

Twenty-eight samples of soil collected at the Dominion Experimental Station, Normandin, Que., in connection with green manuring experiments were analysed for reaction, moisture, loss on ignition, and nitrogen.

Soil work in connection with fertilizer trials carried on in co-operation with the Division of Field Husbandry of the Experimental Farms Service at Charlottetown, P.E.I., Ste. Anne de la Pocatiere, Que., Nappan, N.S., and Kapuskasing, Ont., has been continued. A total of 110 samples from these stations were received for analysis and reported on.

Eight samples of manure from the Experimental Station at Brandon, Man., were examined at the request of the Division of Field Husbandry.

Analytical work was started to study the intake of boron in relation to the application of potash to crops of corn, potatoes, and oats.

Further experimental work to study the occurrence of brown-heart in turnips was carried out in co-operation with the Field Husbandry Division of the Expermental Farms Service. In the spring of 1946 soil samples were taken from the experimental plots and analysed for water soluble boron and soil reaction, and also for nitrogen, available P_2O_5 (Ruhnke), and exchangeable CaO, MgO, K_2O. The boron content of the field was fairly uniform and averaged 0·44 p.p.m., while the soil reaction varied from pH 5·5-7·0. Soil samples were taken in June and twice in July to study changes in the pH during the growing period. At harvest 16 samples (10 uniform roots from each plot) of turnips, roots and leaves, were collected from plots receiving no boron treatment, 15 lb. borax per acre, 45 lb. borax per acre and 45 lb. borax + 50 lb. manganese sulphate per acre. The leaves were analysed for total boron and the roots examined for the occurrence of brown-heart. It was found that an increase in the boron content of the leaves and a decrease in the occurrence of brown-heart in the root resulted from the application of borax. However, it would appear that 45 lb. of borax was not sufficient to give complete control of brown-heart on this type of soil.

Soils from Big Beach, Cape Breton County, N.S., where a deficiency of cobalt was suspected, were analysed. The soils suspected of cobalt deficiency showed a total cobalt content of 2·7 p.p.m. while that representing an area considered to be satisfactory showed 8·9 p.p.m. which is usually considered sufficient for agricultural requirements.

Soils from different areas on a farm at Abbotsford, B.C., where sterility in a dairy herd occurred, were analysed for cobalt, copper, zinc, nitrogen, available phosphoric acid, exchangeable bases, and pH. The results showed that the soil was well supplied with all elements except available potash and lime.

Analytical work was done in connection with the abnormal growth of swedes and mangels in the greenhouse of the Division of Forage Plants, C.E.F., Ottawa. The results indicated that the trouble was not associated with the composition of the soil but rather with the conditions under which the original root was previously grown in the field.

A series of 17 soils collected in the vicinity of Nappan, N.S., which were used in field and greenhouse experiments, were analysed for cobalt, copper, boron, and total and easily reducible manganese. The dykeland soils were higher than the upland soils in boron, cobalt, and copper, but lower in both total and easily reducible manganese.

A total of 486 samples of soil, 16 samples of limestone, and 17 samples of miscellaneous materials were received for examination from farmers, gardeners, and others interested in agriculture. Reports as to general fertility and recommendations in regard to the use of fertilizers were made.

Vitamin and Physiological Research

Research in vitamin and physiological chemistry is fundamental to the maintenance of high productivity of livestock kept under intensive conditions. Investigations of this nature are conducted by the Division of Chemistry in

co-operation with the Experimental Farms and Production Services through the Departmental Vitamin Laboratory. The functions of the combined unit are to undertake research on the fundamental action and practical applications of vitamins and hormones, to conduct chemical and biological assays for the administration of the Feeding Stuffs Act, and to investigate related problems. A report of the service given to implement provisions of the Feeding Stuffs Act is included in the section on Laboratory Services, Plant Products Division.

Research on vitamin A and its precursors has been concentrated on methods of determination and utilization of ingested carotene. A study was made of the influence of various factors and modifications of a standard technique for saponification and extraction of biological materials on the final determination with antimony trichloride or with a spectrophotometer. Results indicate that 0·5g. whole oil need be refluxed for not longer than 20 minutes with 1 ml. of 50 per cent potassium hydroxide. Larger amounts of alkali are not advisable. Values obtained with the Canadian Standard Reference oil showed that under the conditions of this laboratory, the conversion factor to bring extinction coefficient to international units was 2100 for the non-saponifiable fraction and 1900 for the whole oil.

Chromatographic studies were undertaken in making accurate determinations of the carotene content of feed and faeces in connection with the utilization of carotene by ruminants. Several pigments were obtained which had absorption maxima similar to carotene but which had different absorption characteristics.

Carotene is believed to be a precursor of vitamin A and it is common knowledge that ruminants fed carotene-containing feed stuffs do not require additional vitamin A. Co-operative studies with the animal nutrition unit on the fate of ingested carotene by sheep have demonstrated its low coefficient of net absorption. More than 60 per cent of carotene, whether in the form of pure B carotene or as hay, can be recovered from the faeces. Carotene feeding causes no marked change in the vitamin A content of the serum. These results were obtained with normal animals; it is possible that studies during the coming year with vitamin A deficient animals will indicate higher coefficients of net absorption.

Vitamin D supplementation plays a most important role in the productivity of animals housed for long periods. This is particularly true with poultry when the ratio of bone to flesh is large, and when egg production is heavy. The difficulty of assessing chemically the vitamin D content below concentrations of 200,000 units per gram makes the biological test invaluable. The difference in the activity of vitamins D_2 and D_3 for poultry, combined with the fact that poultry consume the bulk of animal feeding oils produced, necessitates the use of chicks in the bioassay. The A.O.A.C. tentative method calls for the use of three or more reference groups and one or more assay groups. This has not proved adequate, and careful studies have shown the necessity of replicating a minimum of three dosage levels to obtain satisfactory estimates of potency. The practical impossibility of improving the present assay method while retaining as a criterion of response the bone ash of three-week-old chicks fed graded amounts of vitamin D, has led to a study of other methods based on other criteria.

Vitamin D action is closely interrelated with dietary calcium and phosphorus intake. Thus the common concept that vitamin D deficiency will result in retarded growth has to be modified. Tests have shown that under certain conditions body weight increase of chicks for the first three weeks after hatching may be identical irrespective of vitamin D administration, while under other dietary conditions vitamin D may retard growth significantly. This

difference in the response to vitamin D is closely linked with the improvement in bone calcification which invariably occurs when vitamin D is added to a D-deficient diet.

Diets differ widely with respect to the improvement in calcification which can be effected by a given amount of the vitamin. A significant response over the basal level having once occurred, however, the ratio response/log unit of vitamin D_3 is the same for all diets studied. This has given rise to the concept of the "rachitogenic index" as a numerical value with which to compare various diets. It may be defined as the $\overline{\text{antilog } \frac{1}{M}}$, where M is a measure of the horizontal distance between parallel log(dose) response curves. The rachitogenic index is a resultant of two factors, *a* the degree of calcification which occurs with the negative control or vitamin D deficient diet and *b* the minimum dose of vitamin D which causes a measurable response. The observation that calcification progresses at the same rate, irrespective of diet, once the initial requirement to initiate a measurable response to vitamin D has been satisfied, has a profound influence on subsequent studies of diets and indeed on the concept of the funadmental action of vitamin D_3.

A study has been made, using x-ray technique, of the progress of rickets when chicks are fed diets giving significantly different negative control responses, although the rachitogenic indices may be similar. When a low Ca diet is fed, there is little change in the degree of calcification until after the seventh day when lack of vitamin D results in rickets becoming increasingly severe with time. When a high-Ca diet is fed, however, x-ray measurements indicate an immediate increase in severity of rickets until the fourth day, after which there is no change until about the twelfth day. After this the degree of rickets increases progressively with time. It is evident that the rachitogenic effect of the two diets is due to differences in the type of "rickets." These studies are being continued.

The use of iodinated proteins in stimulating production in cattle and poultry has been heralded as an instance of the application of science to agriculture. Whether this is indeed fact requires further substantiation.

The development of a bio-assay technique for the determination of the physiological activity of thyrotropic substances has involved the study of the effects of goitrogenic agents on chicks. The employment of anti-thyroid substances affords a means of measuring the hormone production, since drugs such as thiourea and thiouracil produce a measurable hyperplasia of the thyroid gland which can be corrected by the administration of the hormone.

The degree of hyperplasia of the gland is determined by increased thyroid weight and by histological examination. Dissection techniques and tissue staining methods have been compared. The effect of treatment has also been studied by the changes in the cellular elements of blood. It has been found that the metabolic effect of thiouracil is strongly influenced by the route of administration. This drug has been given orally in admixture with dry feeds, in individual pellets containing measured doses, and in aqueous solution. Comparisons have been made with subcutaneous injections.

The optimum dosage level and treatment time interval have been established for female cross-bred chicks.

Excised gland weights of thiouracil-treated birds show that levels of 2·5 to 4·5 mgm. daily per bird over a two-week treatment period produce greater gland hyperplasia than higher levels of the drug.

A partial inhibition has been noted of the goitrogenic effect of thiouracil by small amounts of iodine in the ration, of the order of 0·008 per cent.

The physiological effect on dairy cattle following treatment with thyroprotein has been under investigation in collaboration with the Division of

Animal Husbandry. The metabolic response has been measured by changes in milk and butterfat production, heart rate, body temperature, and respiration.

Preliminary data indicate the need for more extensive investigations to determine optimum dosage levels and general management for substances which produce a powerful thyriodal stimulus.

The determination of excreted estrogenic hormone in the pregnant mare has been made by a colorimetric procedure. Values of sodium estrone sulphate range from 10 mgm. per litre of urine at approximately 100 days to 260 mgm. at 190 days and a gradual decline to 33 mgm. at 7 days before term.

Pregnancy diagnoses of mares have been made by employing both biological tests on blood serum and a chemical procedure on urine.

The tattoo identification of purebred livestock is passing from the experimental stage, and green inks are being used on many classes of livestock. The co-operation of provincial institutions and of farmers has been elicited to demonstrate the legibility of the tattoos under practical conditions. The wide interest in this method of identification is evident from the requests for further information which have been received from different countries.

Branch Laboratories

Kentville, N.S.—

As was mentioned in last year's report a study of the reclamation of flooded dyke land has been initiated. In addition to the analysis of dyke soil for salt, excess sodium, soil reaction, organic matter, and replaceable cations, plots were laid out to which hydrated lime or gypsum or both were added as amendments. The plots were seeded to barley, oats, and grass. The best stands were obtained with increasing increments of both lime and gypsum. Other experiments showed the value of high phosphate fertilizers on this type of soil. In many cases the growth was patchy and the poorer growth was always associated with a high salt content of the soil. The work indicates that 2,000 p.p.m. salt (NaCl) is the limit of crop tolerance.

Work has been continued on apple dehydration and canning studies. Assistance was given to producers through control work on products and investigation and advice in connection with the various processes involved. Studies in connection with evaporated apples showed that if apple by-products are dried to 20-25 per cent, common storage will reduce it to about 20 per cent, whereas if the original moisture is 15-16 per cent, absorption takes place till it becomes about 20 per cent. There are, of course, periods of slight increase or decrease due to unusual weather conditions.

Co-operative work was undertaken with the Kentville Experimental Station on a number of problems. Mulch studies in connection with the growth of small fruits showed that the moisture of the soil was higher under sawdust than under straw mulch. Both these treatments were better than either clean or sod cultivation. Soil samples were analysed from reclaimed and run down orchards and it was found that there was a possibility of magnesium deficiency in some cases. Potatoes from a number of fertilizer plots were examined and the composition related to the fertilizer treatment. Assistance was given in the preparation of a mixture for the treatment of cowpox which had broken out in the station herd. The laboratory preparations gave better control than the usual zinc oxide treatment.

A large number of fruits and leaves were examined for arsenic, DDT, and fluorine residues. It was shown that more soluble arsenic was obtained in the residue when hydrated lime was added to flotation lead arsenate sprays.

Summerland, B.C.—

Apples from plots at Kelowna, Penticton, Summerland and Oliver, B.C., were examined for DDT spray residue. This was to assist in the planning of proper spray schedules for 1947. Of 48 samples examined only two exceeded the tentative allowance of 7mg./kg. In both these cases very severe spray treatments had been given owing to difficulty with the spray equipment. There was good agreement between the strength and number of sprays and the amount of DDT in the residues.

Some time was spent on research and routine testing for the Fruit and Vegetable Products Laboratory. In addition, 573 samples were analysed for Marketing Service Inspectors; these included apple products, dehydrated vegetables, jams and jellies, pickles, fruit pulp, artificial dye, and spaghetti.

DIVISION OF ENTOMOLOGY

Entomological activities in 1946-47 were characterized by a marked increase of emphasis upon forest insects in general and upon the spruce budworm in particular; by more intensive testing of the newer insecticides, especially DDT and benzene hexachloride (666), against a wide range of pests of field crops, gardens, orchards, stored products, livestock, and insects directly attacking man himself; by a more extensive exploration into the role of insect diseases and parasites as a means of combating perennial pests; and by a small but decided shift of emphasis from the highly empirical approach developed under wartime pressures to the more fundamental biological studies that are essential to the proper understanding of the more important insect problems. The dissemination of information on the control of injurious insects again formed a major activity of all field laboratories.

Field Crop Insect Investigations

The wheat stem sawfly is the most serious and widespread insect pest of wheat in the Prairie Provinces. Cultural control measures developed by the Dominion Entomological Laboratory at Lethbridge, Alta., have assisted materially in reducing annual losses which in the past have run as high as 50,000,000 bushels of wheat. During 1946 the phenomenon of diapause in this insect was thoroughly investigated with a view to improving the recommendations for control by means of tillage. The co-operative investigation between the officers of the Lethbridge laboratory and the Dominion Experimental Station at Swift Current, Sask., has resulted in the development of "Rescue" wheat which is resistant to attack by the wheat stem sawfly. Over 200,000 bushels of this seed are available for distribution in 1947. Comprehensive investigations are continuing upon the factors associated with sawfly resistance in different varieties of wheat and barley. Study of the native parasites of the wheat stem sawfly was intensified during the year.

Wireworms are the most widespread of all the insect pests of field crops. These are the larval forms of several species of click beetles and feed on practically all crops except legumes. The aggregate losses caused by wireworms to root crops, grain, tobacco, and grasses are very large though rarely will an entire field of any one crop be destroyed. These insects have a long and complicated life history and are difficult to destroy, especially in potato and vegetable crop areas. The entomological laboratories at Saskatoon, Sask., and Victoria, B.C., are concentrating on wireworm investigations. In 1946 chemical control was emphasized and experiments with some of the newer insecticides indicate that soil fumigation might provide an economical control. Benzene hexachloride was particularly promising both in wheat and potato fields in Saskatchewan.

In Eastern Canada, white grubs are one of the most serious and widespread pests, attacking pastures, grain, root and tuber crops and in one case even destroying valuable nursery stock. These insects have a 3-year life cycle, the most injurious stage occurring in the second year of the cycle, or once every three years in any one locality. The adult beetles, "June beetles", feed on shade trees and were abundant in southern Ontario in 1946. This means that this area should anticipate severe losses from white grubs in 1947, while the area from Ottawa to Sarnia and northward will have a beetle flight in 1947. The Marmora laboratory in the heart of an area severely infested with white grubs, is the field centre for the investigations on this insect. Studies on the chemical reaction of infested soils have revealed a marked correlation between high acidity and white grub abundance. While an effective but laborious cultural program has been developed to reduce losses in cultivated land, recent experiments with soil fumigants indicate that some of these may provide a more efficient and economical control.

The great demand for alsike clover and alfalfa seed and the fact that the seed yields of these crops has fallen off markedly in the last few years have made necessary investigations to determine how much of this reduction is due to insects. Studies on the insects affecting alfalfa seed production have been conducted for several years at the Lethbridge laboratory. It was found that alfalfa seed production was largely dependent on the presence of wild bees to fertilize the blossoms. The lack of bees does not account for all of the losses, and the work at the Saskatoon and Lethbridge laboratories has proved that *Lygus* bugs are also responsible for extensive reductions in alfalfa seed yields. A 3 per cent DDT dust has been found by the Saskatoon laboratory to be an effective control for this insect. The alsike clover seed situation is being studied by the Chatham laboratory in co-operation with the Ontario Agricultural College. Preliminary surveys have indicated that several insects may play an important part in reducing alsike seed yields, and the program is being continued.

The European corn borer is a major pest of corn in southwestern Ontario and southern Quebec, and occasionally invades the corn growing sections of New Brunswick. Investigations on this insect constitute one of the major activities at the Chatham laboratory. During 1946 a project on the use of smokes and artificial fogs in the control of the corn borer was begun at Chatham in co-operation with the Division of Chemical Warfare of the Department of National Defence. Corn borer control experiments are also conducted at the St. Jean laboratory in Quebec.

Tobacco insect investigations are also one of the major projects at the Chatham laboratory. The most important of these are the hornworm which feeds on the leaves and the cutworms and wireworms which destroy the young plants. An effective poisoned bait has been developed for the control of the cutworms. Sprays of arsenicals will control the hornworm but the danger of arsenic residue on the tobacco creates a possible health hazard that cannot be ignored. A dust containing DDT as the poison has given excellent hornworm control.

The pale western cutworm, for several years a serious pest of grain crops in Alberta and Saskatchewan, has been on the increase during the last two years. Some losses were suffered in 1946 and forecasts made jointly by the Lethbridge and Saskatoon laboratories indicate a more widespread outbreak in 1947. Investigations on this insect have been carried on by the Lethbridge laboratory.

Grasshoppers have been one of the major pests in the four western provinces for several years, costing the farmers over $97,000,000 in crops lost during the last ten years. The Provincial Governments have spent in excess of $1,450,000 saved by these expenditures. The headquarters for grasshopper research is

located at the Kamloops laboratory, with staff also placed at the Prairie laboratories to conduct field research and make forecast surveys. Recent investigations in co-operation with the National Defence Experiment Station at Suffield, Alta., show that some of the newer insecticides may be more effective and economical for grasshopper control than the poisoned bait that has been used in the past.

The flax boll worm, a new pest of flax which has appeared in Saskatchewan in the last few years is being investigated by the Saskatoon laboratory. Careful surveys of damage by this species and a detailed study of its biology were continued in 1946. Both cultural and chemical control experiments are being conducted with the object of finding a practical means of checking the spread of this injurious insect.

The sweet clover weevil is increasing in distribution and in importance in the Prairie Provinces. It is reported to be abundant as far west as Lethbridge, Alta., and as far north as Edmonton. Investigations on the biology and control of this pest were intensified in 1946. Different types of tillage in late July immediately after the hay crop was cut, gave from 60 to 90 per cent control, and dusting with 3 per cent DDT also gave encouraging results.

Say stink bug, a serious pest of wheat first appeared in Alberta in 1935. It feeds on the kernels of wheat and flax, causing them to shrivel and be lost in threshing. Investigations on this insect are being continued at Lethbridge.

The pea aphis which affects both field and canning peas is abundant in the pea-growing areas of southern Quebec, eastern Ontario and southern Alberta. Experiments on control methods are being conducted at both the St. Jean, Que., and Lethbridge, Alta., laboratories.

The sugar beet nematode, in southwestern Ontario, and the potato rot nematode in Prince Edward Island, are receiving careful attention. Emphasis is directed toward preventing further spread of these pests and upon the use of the newer soil fumigants as a means of eradication.

During 1946, insects attacking potatoes were given major attention at different points across Canada, where this crop is being grown commercially for certified seed or for table stock. The more important species under study include potato aphids in the Maritime Provinces, the potato leafhopper in Quebec and Ontario, the tuber flea beetle in British Columbia and the Colorado potato beetle and the potato flea beetle in all provinces of the Dominion. A new study station was established at Woodstock, N.B., in the spring of 1946 where special work is being carried out on the four common species of potato aphids. These insects are feared not only because of the actual damage which they cause by their feeding but chiefly for the role they play in spreading virus diseases, such as leaf roll. The biology and migration of aphids is receiving attention and a study of different varieties of potatoes is under way to establish or develop strains which will be resistant to these insects. In 1946, the question of chemical control was investigated and promising results were secured through the use of sprays containing DDT.

The potato leafhopper frequently causes serious crop losses, the yield being reduced by as much as 50 to 75 per cent in extreme cases. Spraying and dusting experiments carried on at Ottawa, Ont. and Messines, Que., indicated that applications of DDT in both spray and dust form gave almost perfect control of leafhoppers. Treated fields, when compared with unsprayed fields, revealed a crop increase of 25 to 50 bushels per acre. This method of control has been generally adopted by the more up-to-date growers in those provinces where leafhoppers are a menace.

A new potato insect, known as the tuber flea beetle, has recently appeared in the lower mainland of British Columbia. This pest attacks both the foliage and the tubers. Damage to the tubers, which takes the form of a pitting and

scarring of the skin, is the more serious as it renders them unmarketable. Entomologists and growers are greatly concerned regarding this insect, particularly as it now appears to be spreading inland to other sections of the province. Extensive control experiments have been carried on at the Agassiz laboratory with very promising results. Dusts containing calcium arsenate or cryolite or DDT, if correctly timed and properly applied, will give effective control. Other promising insecticides, or combinations of such, are being studied.

A perennial and ever present pest from coast to coast, the Colorado potato beetle was under study in most provinces across Canada during 1946. Investigational work centred around the possible use of DDT as a control for this most troublesome and destructive insect. Reports received from all laboratories indicate that in both spray and dust form DDT is superior to all other insecticides so far tested. Dusts containing 3 per cent of the poison and spray concentrations of 1 pound of DDT to each 100 gallons of solution gave almost complete control. Attention is now being directed to determining whether these concentrations can be reduced without seriously affecting the degree of control secured. If this can be done, considerable saving in cost to the growers will result.

Another widely distributed insect attacking potatoes is the potato flea beetle. This minute beetle feeds on potato foliage in the spring and early summer, eating tiny holes in the uppermost leaves. When the beetles are numerous the tops of the plants are killed, which affects the yield adversely. Officers at several laboratories across Canada devoted some time during the year to devising a satisfactory remedy for this species. DDT in both spray and dust form proved to be very effective.

Root maggots of different species are annually occurring pests in most vegetable gardens throughout Canada, and are looked upon as among the most serious encountered. In general, root maggots feed below the ground surface, tunnelling in the roots and cutting off the flow of nutrients to the plant. Plants attacked, quickly wilt and finally die. Plant mortality frequently rises to 50 per cent of the seedlings and transplants. The more important maggots found in Canada are the cabbage maggot, the onion maggot, the seed corn maggot and the carrot rustfly. For the past two years, entomologists have concentrated on a study of these insects, chiefly from the control angle. Results indicate that DDT in different formulations has little value against root maggots. On the other hand, benzene hexachloride has shown definite promise in combating the carrot rustfly and has given encouraging results against the onion maggot and the cabbage maggot.

The turnip maggot, an insect found in most provinces of Canada, is becoming increasingly important, particularly in those districts which are specializing in the production of fancy stock for table use. This pest feeds on the fibrous roots and main tap root, scarring and defacing the latter so that it becomes unfit for market. No completely satisfactory control for the turnip maggot has as yet been devised. The problem is being given special attention at the Charlottetown laboratory. Certain mercury salts were found to be effective, but are too expensive at present prices for general use. Multiple thinning, a special cultural practice, is still the standard control recommendation although far from satisfactory.

During the past few years entomologists in Eastern and Western Canada have devoted considerable attention to the carrot rustfly which is responsible for severe damage to carrots grown in the Maritime Provinces and in British Columbia. Although this insect shows a distinct preference for carrots, it attacks also parsnips and celery. In the coastal regions of British Columbia it is particularly destructive but is looked upon as a pest of economic importance in parts of Nova Scotia, New Brunswick and Prince Edward Island. Research work in 1946 centred around a study of control. Some of the new insecticides,

such as DDT and benzene hexachloride, were tested in comparison with the standard remedies, chiefly napthalene flakes and a 4 per cent calomel dust. Benzene hexachloride, applied as a dust to the foliage of the carrot plants and to the soil beneath has shown most promising results. The chief entomologist for Newfoundland kindly co-operated this year in carrying out a test paralleling the British Columbia work. The results matched almost perfectly. Benzene hexachloride was found to be superior to any other chemical, followed in degree of effectiveness by naphthalene flakes, calomel and mercury bichloride in that order.

For some years past, shipments of parasites of the pea moth have been made from the Dominion Parasite Laboratory, Bellevile, Ont., to areas in British Columbia where this insect is abundant. In 1945 collections and dissections of pea moth caterpillars indicated that these parasites had become established and were markedly reducing the pea moth population. Continued shipments of parasites were made from Belleville this year to ensure that the new parasite colonies survived and did not become weakened or die out. In the fall of 1946, a collection of 20,000 pea moth caterpillars was made in sections of British Columbia where parasite liberations had been made during the past few years. These were sent to the Dominion Parasite Laboratory for observation and study. Dissections of these larvae showed a high percentage of parasitism. This material is being utilized to increase the parasite supply for shipments to British Columbia in 1947.

In 1946, a preliminary test of DDT against cutworm was made in a market garden at Grand Forks, B.C., where the production of vegetable seed is the main activity. Surface applications of a 3 per cent DDT dust, at a rate of 100 pounds per acre, quickly resulted in a cutworm mortality of approximately 50 per cent. This was about the same control secured from poisoned bran bait, the commonly recommended remedy. Although the point was not investigated at the time, it is thought that the DDT dust would have a much greater residual effect than the bait. Further tests are planned.

A local but severe outbreak of the purple-backed cabbage worm occurred at Red Point, P.E.I., in the late summer of 1946. As this insect is by no means common, the opportunity was taken to test the effectiveness of DDT on the caterpillars. It was applied as a 3 per cent dust and as a spray at standard strength. These treatments were checked in comparison with calcium arsenate in spray form, the formerly recommended remedy. The results were most satisfactory. DDT, both as a spray and a dust, gave almost complete control while the calcium arsenate was shown to have little real value. In earlier years, when outbreaks of this insect occurred, entomologists were at a loss to know what to recommend, since none of the known insecticides had proved effective.

Attention has been drawn in the discussion on root maggots to the apparent effectiveness of benzene hexachloride against soil-infesting insects. This characteristic has been demonstrated in carrot rustfly tests made in Newfoundland, in onion maggot experiments carried out in Manitoba, and in trials with the cabbage maggot at Chatham, Ont. Benzene hexachloride has also shown considerable promise as a control for wireworms in field and laboratory tests in Saskatchewan. It must be understood that these findings are the result only of relatively small experimental tests carried out on a variety of insects in different parts of the country over a period of two years. However, the fact that benzene hexachloride has shown merit as a soil insecticide is most interesting since satisfactory insect poisons for use in the soil are rare. The discovery is of particular interest at this time, following the apparent failure of DDT to check insects commonly infesting the soil in experimental work carried out during the past two seasons in different parts of Canada.

Fruit Insect Investigations

In Nova Scotia long-term investigation of the effect of spray materials on the natural control agencies in apple orchards is beginning to yield very significant information. Studies extending over a four-year period have shown that the important natural enemies of oystershell scale in Nova Scotia are a chalcid parasite and a predaceous mite. Although some scale can be found in every orchard in the Annapolis Valley these natural enemies are normally sufficiently abundant to keep the scale from becoming injurious if other factors do not interfere. Tests with various fungicides applied for scab control have clearly indicated that sulphur treatments are detrimental to both the parasite and the predator, and if continued over a period of years, suppress them so much that outbreaks of scale are sure to follow. On the other hand copper fungicides and a new organic fungicide, Fermate (ferric dimethyl dithiocarbamate), are not markedly injurious to the natural control agencies, so that the latter are able to hold the scale in check in orchards where these fungicides are used in place of sulphur. Similarly, the recent increase in European red mite in Nova Scotia has apparently been caused by the use of sulphur which destroys the predaceous mites and insects which would otherwise keep it under control. When copper fungicides, relatively harmless to these predators, are substituted for sulphur, red mite is generally kept at a low level by these natural enemies.

Tests on the control of the strawberry mirid, *Calocoris norvegicus* Gmelin, a very destructive pest in Nova Scotia, have again demonstrated the value of DDT, a spray of $\frac{1}{2}$ pound actual DDT per 100 gallons giving very good control. Benzene hexachloride at 0·6 pound gamma isomer also gave excellent results, but sabadilla was quite ineffective.

In Nova Scotia, a dormant spray of benzene hexachloride dissolved in stove oil to give 0·15 pound gamma isomer per 100 gallons when the oil was applied as a 5 per cent emulsion gave good control of eye-spotted budmoth; DDT used in the same manner gave nearly as good results.

A pre-blossom spray of DDT in bordeaux gave decidedly better control of strawberry weevil in New Brunswick than DDT used in other formulations or at other times, or the recommended cryolite-gypsum dust. Besides giving earlier and more persistent protection against weevil this combination spray affords control of fungous diseases. Benzene hexachloride gave no control of this insect.

Against eye-spotted budmoth a summer spray of DDT at 1 pound in Velsicol emulsion gave best results, followed by DDT spray powder; both were better than nicotine sulphate at 1 quart per 160 gallons. All materials were used in combination with lead arsenate and bordeaux.

In the laboratory, an extensive program of tests of insecticides for aphid control was carried out, particularly to find the most efficient materials for field control of potato-infesting species. Results show that DDT in Velsicol emulsion is from five to six times more toxic to the aphid, *Myzus persicae,* than the wettable form. It was also shown that both forms of DDT are more toxic when used in combination with 10-10-100 bordeaux than when used alone, and that the fixed coppers also increase toxicity of DDT but not to so great an extent. Sabadilla when used in water alone at the rate of 5 pounds per 100 gallons produced a low kill. Early tests with benzene hexachloride produced very erratic results but final tests with this material gave complete control when used at the rate of $\frac{1}{4}$ pound gamma isomer per 100 gallons in combination with 10-10-100 bordeaux. When used alone and in combination with the fixed coppers the toxicity was lower.

In Quebec, a paste of crude benzene hexachloride (13 per cent gamma isomer) mixed with either summer oil or water, failed to give as good control of round-headed apple-tree borer as the standard calcium cyanide-linseed oil treatment.

Orchard spraying experiments during 1946 in Ontario have proved that DDT is outstandingly the most effective insecticide for codling moth control yet discovered. In the Ontario trials six cover sprays each containing 1 pound DDT gave 98 per cent or more clean fruit in one of the most heavily infested orchards in the Niagara district. Chemical analysis of apples at harvest showed there was no danger of excessive DDT residue from a properly arranged schedule under Canadian conditions. Benzene hexachloride was of no practical value against codling moth in orchard tests.

European red mite increased very noticeably in the plots where DDT was used; xanthone or the sodium, ammonium or dicyclohexylamine salts of dinitro-cyclohexylphenol in the last three sprays of a six-cover DDT schedule on apples kept the mite in check, but 1 per cent summer oil was the most effective material used. This strength of oil cannot be used with DDT at 1 pound because of foliage injury, but a schedule in which sprays of DDT at 1 pound per 100 gallons alternated with applications of the standard lead arsenate-oil gave good control of both codling moth and red mite.

Because the resulting outbreaks of plant-infesting mites form one of the chief obstacles to the more general use of DDT, a large number of materials both new and old were given preliminary tests as acaricides against red spider mite in the greenhouse. Most have been discarded but certain newer and very promising compounds will be given further investigation.

Research on oriental fruit moth control on peaches in Ontario involved both the use of laboratory-reared parasites, in co-operation with the Dominion Parasite Laboratory at Belleville, and control by sprays of DDT. In the spray trials two applications of DDT at 1 pound per 100 gallons were made on Elberta approximately six and three weeks before harvest. The sprays reduced total fruit moth injury from 17·3 per cent to 6·5 per cent in one orchard and from 18 per cent to 5·6 per cent in the other orchard. A 90 per cent reduction in externally invisible injury, which cannot be culled during packing, was especially significant. Nevertheless DDT cannot yet be generally recommended for a number of reasons, most important being its effect on the parasites of the fruit moth. The Canadian investigations have not continued long enough to reveal this effect, but experience in the United States indicates that extensive use of DDT over a large area will destroy the parasites so that growers will be forced to rely entirely on sprays for moth control. This might be very difficult because close planting in many orchards does not permit efficient spraying. European red mite also became very abundant in the experimental plots sprayed with DDT, and the cumulative effect of yearly spraying may lead to severe outbreaks. The parasites of scale insects also appeared to be very susceptible to DDT. For these reasons DDT is as yet recommended only tentatively for those orchards in which parasites usually fail to give satisfactory control, or for a few very late varieties, ripening later than Elberta, which are especially subject to fruit moth injury.

In tests of summer sprays against eye-spotted budmoth on apple trees, DDT in summer oil emulsion gave very high kill of young larvae on the foliage, in contrast with former tests where DDT was used alone.

Results of spraying experiments against grape berry moth in Ontario showed that a three-spray DDT-bordeaux schedule was somewhat more effective than a similar lead arsenate-bordeaux schedule, but the latter when thoroughly applied gave very good control. Grape leafhoppers were completely eliminated from

the DDT plots whereas the addition of nicotine sulphate to the post-blossom application was necessary in the lead arsenate plots. Ploughing, particularly in the spring, reduced the amount of injury from berry moth.

Usually of very minor importance, a severe outbreak of grape blossom midge occurred in some vineyards in the Niagara district in 1945. Control experiments correlated with life history studies were undertaken in the spring of 1946. A spray of DDT 1 pound in 100 gallons of bordeaux, applied on June 4 just as the adults began to emerge when four to five leaves were showing on Concord shoots, gave 86 per cent control of the light infestation which prevailed this year.

Both a spray and a dust of DDT were compared with the standard bordeaux treatment for potato leafhopper control on apple nursery stock, three applications being made in each case. Both DDT plots showed less leaf curl resulting from hopper feeding, and the stock from these plots also yielded a greater proportion of trees in the two highest grades than the bordeaux plot.

An intensive program of insecticide research was carried on in the laboratory, including preliminary trials of a number of newly introduced insecticides and investigations on the more fundamental aspects of older ones. Of the new materials a number were very toxic to some species of insects and will undoubtedly be valuable for certain specific uses, but none appear to approach DDT in general usefulness; in particular they lack the remarkable persistence of DDT. Benzene hexachloride has been used in large-scale experiments against a number of insects and the more important results are given elsewhere in this report. In the laboratory it was found to have marked fumigant action because of its volatility. For the same reason it lacked persistence and its effectiveness was much reduced by air currents. Its toxicity was not appreciably affected by use in combination with such fungicides as bordeaux, fixed coppers, Fermate or sulphur. Two other chlorinated hydrocarbons, Velsicol 1068 and Hercules Toxicant 3956, were both effective contact insecticides against aphids. Velsicol 1068 showed fumigant action; its toxicity was lowered by air currents and it had poor residual action. It showed promise against tarnished plant bug but was comparatively ineffective against diamondback moth larvae. Hercules Toxicant 3956 appeared to be less volatile than Velsicol 1068 and its residual action against potato leafhopper was good; it also gave good control of aphids but was much less effective than DDT against diamondback moth larvae. Unlike the materials previously mentioned, hexaethyl tetraphosphate was very effective against the active stages of red spider mite, but did not kill the eggs and had little residual action. It was also very toxic to aphids and mealy bug nymphs.

In British Columbia the great effectiveness of DDT for codling moth sprays was confirmed. Three cover sprays of DDT at 1 pound or five at $\frac{1}{2}$ pound gave satisfactory control. Work in this province included grower trials in which seven growers each applied a tank of DDT at $\frac{1}{2}$ pound per 100 gallons for comparison with the regular schedule of either 4 pounds cryolite in all covers, or phenothiazine in first brood and fixed nicotine-oil in second brood covers. Even at this low dosage, five of the growers obtained better codling moth control with DDT than with the regular schedule; two obtained no better results. These trials in small plots probably do not do justice to the value of DDT since its use on a larger scale has generally given more outstanding results. This apparently results from the toxicity of DDT residues on the foliage to the adult moths. As in Ontario, benzene hexachloride gave very poor control of codling moth.

The problem of controlling fruit-tree-infesting mites in British Columbia has become particularly important since the advent of DDT. In British Columbia, xanthone or the dicyclohexylamine or ammonium or monoethanolamine

salts of dinitrocyclohexylphenol, used in DDT codling moth sprays, gave satisfactory control of both European red mite and Pacific mite. Finely divided elemental sulphur used in all applications with DDT, controlled Pacific mite well but failed to control European red mite.

Under Okanagan conditions an application of heavy dormant oil 4 per cent or heavy dormant oil 2 per cent plus dinitrocresol appeared to give adequate control of pear psylla. Summer treatments of nicotine sulphate-soap, derris-summer oil and benzene hexachloride-summer oil or distillate oil were all sufficiently effective to control at a single application the worst infestations that developed during a cool season when high water raised the atmospheric humidity of pear orchards situated close to lake level. The effectiveness of the oil-benzene hexachloride spray was particularly noteworthy because in Ontario summer sprays of benzene hexachloride wettable powder (4 per cent gamma isomer) even at 5 pounds per 100 gallons failed to control psylla and caused noticeable foliage injury. Although generally distributed, the pear psylla caused practically no economic loss in the Okanagan Valley in 1946. Spray treatments were necessary in only a few cases.

Dormant treatment with oil-dinitrocresol and oil-DDT gave high kill of over-wintered larvae of the peach twig borer in British Columbia. Similar results were obtained from a pink spray of lime-sulphur, dormant strength. When used without oil, water-soluble dinitrocresol (sodium salt) seemed relatively ineffective even at fairly high concentration. Results from the use of a shuckfall treatment of cryolite-summer oil were inconclusive. The peach twig borer has lately shown a resurgence of activity and last year was a very destructive pest of peaches and apricots in a number of South Okanagan orchards.

Experiments in control of San Jose scale which attacks tree and bush fruits in the Okanagan Valley, were continued for a second year. Dormant oil of 200-220 S.S.U. viscosity was more effective than oil of 100-110 viscosity as currently recommended by the Western Spray Project. In 1947 the heavier oil will be recommended exclusively in place of 100 viscosity oil in the Okanagan Valley. Lime sulphur-dormant oil mixture for the second year was more effective than either lime sulphur or dormant oil alone. Dormant oil—dinitrocresol did not control San Jose scale well enough to be used in cases of scale incrustation. The same applied to dormant oil-DDT where DDT was used in amount equal to dinitrocresol. San Jose scale infestations have become exceedingly difficult to control in some orchards in the South Okanagan, presumably due to excessive incrustation.

A two-year investigation of control of pear thrips was concluded with the discovery that a dormant application of DDT at $\frac{1}{2}$ pound per 100 gallons gave very satisfactory results. In the past, pear thrips has been one of the British Columbia fruit insects most difficult to control, and, where conditions are to its liking, one of the most injurious.

A second year's investigation of the effect of DDT on buffalo treehopper attacking apple trees has supported the conclusion reached in 1945 that application of DDT spray as the treehopper eggs are hatching in spring and again when adults are migrating to the trees in the fall, apparently gives a considerable measure of control. Either treatment alone has not been sufficient.

Sprays of $\frac{1}{2}$ pound gamma benzene hexachloride in 100 gallons of $\frac{1}{2}$ per cent distillate or summer oil emulsion gave better control of woolly apple aphid, mealy plum aphid, black cherry aphid and green apple aphid than the usual spray of 1 pint nicotine sulphate per 100 gallons in British Columbia, and appears to be the best insecticide yet examined for orchard aphids. It may be especially valuable for control of woolly apple aphid infestations which follow the use of DDT for codling moth control.

White grubs of a distinctly different type from those occurring in Eastern Canada are a serious pest of strawberries on Vancouver Island. The recent development of cheap and effective soil fumigants has offered a new approach to their control. Three of these, ethylene dibromide, D-D mixture and benzene hexachloride, which were applied in the fall of 1946 did not appear to injure strawberry plants seriously, but their effect on the grubs will not be known until the summer of 1947.

Experiments were continued in British Columbia with the object of obtaining badly needed information on chemical or physical characteristics of petroleum fractions that might give satisfactory indication of their insecticidal effectiveness on the one hand, or their tendency to cause injury to fruit trees on the other. Oils from mid-continent crude (high viscosity index) have been considerably more effective in controlling San Jose scale than oils of similar viscosity from California crude (low viscosity index). The mid-continent oils have also shown greater tendency to cause injury. Dormant oils of 200 S.S.U. viscosity have been more effective in scale control and less injurious to trees than oils of 100 S.S.U. viscosity. Oils of low A.P.I. gravity were in general more difficult to emulsify than those of higher A.P.I. gravity and tended to cause more tree injury. Unstable emulsions tended to result in heavier oil deposits than stable emulsions. Oils of low flash point seemed in general, more injurious than those of high flash point.

A turbine sprayer-duster obtained by the Summerland, B.C., Laboratory in the spring of 1946 was used in orchard experiments on codling moth control and to a limited extent in experiments on mosquito control. This equipment is still in the experimental stage but appears to have good possibilities in the application of the newer insecticides in British Columbia orchards. It gave satisfactory control of codling moth when DDT-talc dust was ejected simultaneously with stove oil emulsion. Spray deposits tended to be somewhat too high but treatment of large blocks of trees should tend to lessen irregularity of deposit. The turbine sprayer-duster can be easily hauled by a light tractor and is operated with little effort by one man. It appears to be about five times as fast as the conventional two-gun high pressure sprayer. One of the important investigations in 1947 will be the continuance of experiments with the turbine sprayer-duster. During 1946 many changes and improvements were made in the machine, and the 1947 trials will be on a much larger scale than those of 1946.

Forest Insect Investigations

There has been an unprecedented demand on the part of the pulp and paper and lumber industries for intensification of investigative work leading to the development of adequate methods of prevention and control of forest insect epidemics. To meet this demand, the activities of the forest insect investigations unit have been expanded by a material increase in personnel and research facilities. The work of the unit is so arranged that the laboratory at Sault Ste. Marie is the co-ordinating centre for the Canada-wide Forest Insect Survey and the basic research centre for forest insects in general.

The Forest Insect Survey is a co-operative project organized in 1936 for the timely detection of outbreaks and the general study of the distribution of insect species from coast to coast. It is the principal source of topical information on insect activity and serves as a basis for the planning of research and control operations in all parts of the Dominion. Some 2,500 observers belonging to the ranger staffs of the provincial services, the protective associations and the companies make regular reports on the forest insects occurring in the territories under their supervision. During the past year, a total of 13,339 such reports were received at the various regional laboratories.

At present 42 specially trained forest insect rangers appointed by the Dominion Department of Agriculture act as leaders and contact-men in the organization and the performance of the field work. In addition to instructing the co-operating personnel, they make special reports on insect conditions, the status of outbreaks, and the nature and amount of losses incurred in their respective districts. Since the appointment of these insect rangers both the quantity and the quality of reports made by co-operators have been greatly improved. Greater accuracy in taking samples of insect populations has led to the discovery of numerous incipient outbreaks, a fact greatly appreciated by the limit holders and operators concerned. In Quebec, the survey is conducted by the provincial entomological service in close co-operation with the Dominion Division of Entomology, and the results of the provincial survey are incorporated in the Annual Report published by the Dominion.

The most destructive forest insect in 1946 was undoubtedly the spruce budworm. Throughout the main body of the outbreak, extending eastward from Lake Superior to the Quebec boundary, the infestation appears to be subsiding, leaving a high percentage of dead and dying balsam fir and white spruce. Within this region, areas of heavy infestation still remain in the Chapleau and Gogama forest districts. To the north and west, on the fringes of the original outbreak, there are a number of active infestations varying in intensity from moderate to severe in the Mobert, Hearst, Kapuskasing, and Lake Abitibi areas. The most serious outbreaks, however, occurred still farther west, namely in the Lake Nipigon, Sioux Lookout and Lac Seul areas in northwestern Ontario and in the Spruce Woods Forest Reserve in Southern Manitoba. Of these, the Lake Nipigon outbreak was the largest and most severe. To the east, in Quebec, the currently most serious infestations are in the St. Maurice River Valley and Lake St. John areas. These outbreaks threaten large areas of spruce-balsam forest farther east on the north shore of the St. Lawrence. Other outlying areas where outbreaks occurred were in the North Thompson Valley and at points near Vernon and Lake Louise in British Columbia.

The greater part of the entomological investigations in Eastern Canada have been concentrated on various aspects of the spruce budworm problem. Intensive studies of the reaction of the spruce budworm to physical factors of the environment, light, temperature and humidity have been undertaken at the laboratory at Sault Ste. Marie. An intimate knowledge of these relationships is essential to an understanding of migration and spread of infestations and is basic to practically all work conducted for the purpose of determining fluctuations in the numbers of insects, the role played by natural control factors, the most effective methods and the timing of artificial control measures. These studies instituted in 1946, have already yielded important new information on the behaviour of budworm larvae under varying climatic conditions as related to the available food supply.

Closely related to the above is the study of sampling techniques to determine the upward or downward trends of local insect populations. Knowledge of these trends is indispensable in planning control or salvage operations. Owing to the excessive variability of the environment under forest conditions, it is extremely difficult to devise adequate sampling systems. However, considerable progress has been made in this respect during the past season and the investigation will be continued and expanded in 1947.

Although a great amount of excellent work has been done in the past on the study of the life history and habits of the spruce budworm, many important aspects of the biology of this insect stand in need of further research. This applies particularly to the early stages of larval development, a very critical period in the sequence of events attending the rise and fall of outbreaks. The

overwintering habits of the young larvae and their mode of nutrition have been carefully investigated to determine the rate of survival. Dispersal of these larvae by winds upon emergence in spring is another important factor in the spread of infestations to which considerable attention has been given. Finally, the effect of weather in April and May, especially late frosts, both as it affects the trees and the larvae, has been found to influence very profoundly the intensity of outbreaks during the following summer. Larval mortality resulting from late frosts has been found, by actual counts, to range from 6 to 62 per cent.

Studies of parasites attacking the spruce budworm show that these insects destroy variable amounts of the budworms which have survived unfavourable weather conditions in spring. In the early stages of an active, rising infestation usually the proportion of the well-grown larvae destroyed by parasites does not exceed 10 per cent; and of pupae, 5 to 10 per cent. With prolongation of the outbreak, the parasite populations rise, the host population tends to drop through partial exhaustion of the food supply, and increasing proportions of the larvae and pupae are killed by parasites. In some instances, one-third to one-half of the well-grown larvae, and similar proportions of the pupae, are destroyed by parasites. Such comparatively high control by parasites seems, in Ontario, to be confined to the later stages of an outbreak, when damage to the timber has already been done, and therefore while contributing to the rapidity of decline of outbreaks, the native parasites, so far as known, have not prevented the rapid rise and extension of such outbreaks.

Various parasitic species, not native to Ontario, have been released in this province through the Belleville Parasite Laboratory, in an effort to establish more effective agents for the control of the spruce budworm. One of these, *Phytodietus fumiferanae,* obtained from British Columbia, has been recovered in the Black Sturgeon Lake area from budworm larvae in the vicinity of the point of release.

The spectacular reduction of the recent European spruce sawfly outbreak in Eastern Canada by a virus disease followed by similar incidents in the case of the black-headed budworm and the hemlock looper in British Columbia has greatly stimulated the interest of the public in the possibilities of using disease organisms in the control of the spruce budworm. Previous research on the natural control factors affecting budworm populations failed to disclose the existence in North America of any type of disease organism which might be of value in combating the insect. During the fall of 1946 a preliminary investigation of possibilities existing in Europe was undertaken. Subsequently arrangements were made with the Imperial Bureau of Biological Control to send two investigators to the European continent to organize the study and collection of disease material affecting two closely allied budworm species occurring in Central Europe. In the meantime, more intensive investigations of the biological control agents active in Canada have revealed the existence of important virus, bacterial and fungous diseases which, when artificially propagated and distributed, may eventually play a major part in the reduction of budworm outbreaks. These organisms as well as those imported from Europe will be investigated at a special pathological laboratory now under construction at Sault Ste. Marie, Ont. Suitable and promising disease agents will ultimately be produced on a large scale by the same institution and will be liberated in infested areas.

The sex ratio of a species (proportion of females to males) is an important factor in connection with the potential rate of population increase. The ratio may fluctuate from place to place, and at different times in the outbreak cycle, as a response to environmental factors, if one sex is less resistant than the other to unfavourable environmental conditions. A cytological technique has been discovered whereby sex can be determined in the newly hatched larvae as well

as in the older ones, and this makes possible the determination of the sex ratio at all developmental stages of the spruce budworm. It provides a valuable tool for the accurate determination of differential mortality of the two sexes at different times during development and at different periods in the outbreak cycle. Preliminary results based on cytological examinations suggest that more female eggs than male eggs are deposited by the budworm moths (the ratio cannot be stated with accuracy as yet on the basis of available data); and that at time of hatching, the two sexes are approximately equal in numbers, which suggests somewhat higher mortality of the females during the incubation period. The sex of the pupae and of the moths is easily determined by microscopic examination.

Investigations to determine the influence of stand composition and of proximity to heavy outbreak centres on damage resulting from a sustained spruce budworm outbreak were commenced in the Algoma Region in 1946, as a joint project with the Department of Lands and Forests of Ontario. Surveys were carried out in the Mississagi River Valley, the Ranger Lake region and in the Montreal River area. In each locality cruise lines were run at successive intervals and detailed tallies of all tree species, classifying each tree as living or dead, were made. Careful notes were also taken on forest composition, site characteristics and developmental history of the stand. Certain portions of the survey lines were marked for re-examination in subsequent years, and small plots were established for periodic study of the regeneration. In the Mississagi territory damage has been exceptionally heavy near the southern boundary of the outbreak. Balsam fir mortality ranges between 80 and 100 per cent, including all merchantable sizes and a large proportion of the smaller diameter classes. From 24 to 30 per cent of the white spruce has been destroyed. In one locality white spruce mortality in a mixed forest type amounted to 80 per cent. In other sections of the territory, an increased mortality of balsam fir and white spruce becomes evident as the centre of the old outbreak is approached. In some cover types, white spruce mortality ran from 94 to 100 per cent. High mortality of black spruce was usually associated with its occurrence in heavy mixtures of white spruce and balsam. Pure black spruce stands were not seriously affected. One of the most important observations made in the Ranger Lake Road area is that equally high mortality of balsam fir and white spruce occurred in mature, virgin mixed forests as in mature virgin coniferous stands, and only slightly less in the mature, virgin hardwood forests. This is contrary to the findings of investigators, who from studies of earlier outbreaks in Eastern Canada arrived at the conclusion that a hardwood crown canopy gave effective protection to an understory of balsam fir and white spruce. In the Montreal River area it was found that black spruce was rather seriously injured, the average mortality being about 30 per cent, with one stand, in a virgin coniferous forest, showing a loss of 72 per cent. The conclusions derived from these investigations will be of outstanding value in formulating any recommendations for the management of forests menaced by the spruce budworm. It is expected that similar surveys will be undertaken in other parts of Ontario.

In 1946, the Department of Lands and Forests of Ontario in co-operation with the Dominion Division of Entomology conducted a large-scale spraying operation in the Eaglehead Lake area, about 50 miles north of Fort William. The plan provided for the treatment of 35 square miles of forests, using a Canso Model A aircraft to distribute the DDT sprays. Because of the density of the forest stand, it was decided to spray at the rate of 2 gallons per acre. This required a delivery of 116 gallons per minute and a new type of equipment was recommended to replace the simple gravity-fed apparatus used on the Cansos in 1945 which delivered only 40 gallons per minute. The new equipment gave excellent performance and produced an exceptionally uniform spray pattern. Ten test plots were sprayed to obtain additional information on dosages and

effectiveness of various types of sprays. The remainder of the area was treated as a large-scale spraying project. A field camp was established on Eaglehead Lake for the purpose of marking out the plots, and appraising the degree of control obtained. The aircraft was operated from the Fort William airport and the ferrying distance to the project area was about 51 miles. The plane delivered an average of 550 gallons on each trip, flying at 140 miles per hour at an altitude of 150 feet and with an effective swath of 200 feet, treated 56·56 acres per minute. Ninety-six loads were sprayed over an area of approximately 40 square miles. During the course of the project some 60,000 gallons of spray and 35 tons of DDT were used. In determining the effectiveness of the operation some 500 sampling stations at intervals of 132 feet were established across the area. An enormous amount of data relating to the percentage control obtained, DDT deposit, spray spectrum, drift, spray action under various meteorological conditions, effect on wild life, time and costs, etc., has been analysed. From observations in the field at the conclusion of the operation, it seemed evident that the budworm population had been almost entirely eliminated in the sprayed area. Defoliation was also very light in 1946, in contrast with heavy defoliation in the surrounding unsprayed forest. The ultimate effects of the operation on the budworm infestation in the sprayed area, and on the sprayed forest, can only be determined in 1947 and subsequent years.

It is generally conceded that the most effective weapon in the struggle against the spruce budworm is found in appropriate forest management. Its principal object is prevention rather than control, and it is only in combination with it that other remedial measures will attain the fullest degree of efficacy. With a view to devising methods of forest management which will be conducive to budworm control through immunization of the forest, a large-scale project was initiated in 1944 as a co-operative enterprise sponsored by the Canadian Pulp and Paper Association. An area of 500 square miles, known as the Green River watershed and operated by the Fraser Companies Limited of Edmundston, N.B., was selected as the site of the experiments. The Dominion Forest Service, the New Brunswick Forest Service, the Fraser Companies Limited and the Division of Entomology take an active part in their respective fields of endeavour. Considerable progress was made during the last year both in the forestry aspects and the entomological phases of the investigation. With regard to the latter it is reported that up to the present time, the budworm population has remained at a low level and that this condition is apparently very largely the result of several natural control factors. About 50 per cent of the larvae collected are attacked by native parasites. Birds destroy a large percentage of the pupae. No appreciable defoliation has been noted to date. Several plots have been established for the study of previous outbreaks and their effect on the stand. The Dominion Forest Service has prepared a 5-year working plan calling for an annual cut of 65,000 cords from the entire area under management. Fifty thousand cords will be cut in that section of the watershed, which is considered most vulnerable to budworm attack. It is estimated that by this procedure a considerable part of the most susceptible stands can be removed before the current outbreak spreads into the Maritime Provinces.

The jack pine budworm, a species closely allied to the spruce budworm, was on the whole less prevalent and less destructive in 1946 than in previous years. Only two centres of medium to heavy infestation were recorded in Manitoba, namely the Sandilands Forest Reserve and the Whiteshell Forest Reserve. In 1945, an active infestation was discovered in Ontario in the Sioux Lookout district and persisted through 1946, another outbreak covering some 25 square miles was found in the vicinity of Sultan, southeast of Chapleau. Intensive studies of natural control agencies tend to show that parasitism by itself, though an important factor, cannot be considered the principal cause of the subsidence of

outbreaks. The highest mortality in the larval stage occurs early in the season, before the insect becomes permanently established in the new growth or in the opening flower cones, and must probably be ascribed to physical factors.

The bronze birch borer, probably in association with other, as yet unknown factors, is the cause of widespread dying of birch in New Brunswick, Nova Scotia and Quebec. The utilization of birch for veneer, ties, fuel and lumber having greatly increased in recent years, protection and conservation of this species has become a problem of major importance. The solution will be found mainly in the adoption of appropriate methods of management. Several years of intensive study at the Fredericton laboratory have led to the following recommendations: Present old growth stands in which mature and overmature hardwoods, including injured birch, form a large proportion of the stand should generally be completely clear cut. This means removing all possibly merchantable trees and cutting or killing all unmerchantable defective trees to make way for new growth. Killing by girdling is not recommended as girdled trees are particularly favourable to borer breeding. Poisoning may be practicable. It is doubtful if anything will be gained by leaving any of the smaller hardwoods as these are likely to become wolf trees or die before the next cut. Seed trees are also of doubtful value as the nature of the next crop has already been determined, as a rule, by the advance reproduction. Old growth stands which have been opened up by past cuttings or "dieback" for a sufficient length of time, so that they contain considerable quantities of young promising trees, should be partially cut to remove the mature and defective trees with a minimum of disturbance to the young stand. Where possible, cutting trees in groups should be favoured and particular care should be taken not to leave birch severely exposed. Where even-aged stands of white birch, aspen, etc., have grown up as an overstory to softwood on old burns, the birch and other hardwoods should be cut as soon as merchantable, in order to release the softwoods and remove birch becoming weakened by competition and favourable to the borer. Such operations might often be justified at a loss on these grounds. The proper treatment of young hardwood stands needs futher study but thinnings, or other improvement cuttings, should not be heavy. Birch with any signs of "dieback" should be removed but care taken to prevent injury, or exposure of vigorous young trees.

The European spruce sawfly is present over the greater part of the territory infested in former years but has remained at low population levels in 1946. A virus disease and the introduced parasites are responsible for this condition. Since the termination of the outbreak, when disease reduced the numbers to a very low level, the population has tended to rise but the percentage killed by disease and parasites has increased with the numbers of the sawfly. Judging from its behaviour at this point during the past 6 years, it would appear that as long as the disease maintains its present degree of virulence in relation to the sawfly, and does not disappear, it will be capable by itself of preventing the sawfly from becoming numerous enough to cause serious defoliation. The presence of the parasites, on the other hand, constitutes an insurance against a possible reduction in the effectiveness of the disease, and this combination of control factors seems likely to prevent a repetition of the previous widespread outbreak. Dried extract of diseased larvae has been used to establish the disease in Newfoundland, in co-operation with the Newfoundland Forest Protection Association. Prior to its introduction no diseased larvae had been found on the island, but the disease is now prevalent over considerable areas surrounding the points of liberation.

Larch sawfly investigations have been continued in all parts of the Dominion. The new stands now replacing the old larch destroyed in the early part of the century, are gradually attaining commercial size and are rapidly increasing in value. At the same time, it is feared that with approaching

maturity their resistance to repeated attacks by the larch sawfly will diminish very noticeably. Close watch is being kept on the efficacy of the imported parasites in keeping down sporadic, local outbreaks. In Manitoba, there seems to be a marked decline in the parasitism by *Mesoleius aulicus* whilst another species, *Bessa harveyi* is definitely on the upgrade. The cause of the decline in the efficiency of *Mesoleius* is under investigation and may ultimately lead to new procedures in parasite liberations. Meanwhile, serious thought is being given to the possibilities of such other methods of control as forest management, propagation of disease organisms and the distribution of insecticides from aircraft. In British Columbia, field observations show that for the third consecutive year the population of the sawfly has remained at a low level in the southeastern section of British Columbia where the insect has been present for 6 years or more. Annual sampling throughout this area from the time of the first appearance of the sawfly has shown an initial build up of the population lasting 5 or 6 years, followed by a subsidence and apparent levelling off. The sampling has further shown that the introduction and colonization of the parasite, *Mesoleius tenthredinis* has played an important part in reducing the sawfly to its present status. Other factors which have assisted in the control of the insect are the parasite, *Tritneptis klugii* (also European in origin), the fungus *Isaria farinosa,* rodents, and a few insect predators of lesser importance. Throughout the larch stands of British Columbia there has been no tree mortality directly due to sawfly injury.

During 1946, severe infestations of the western hemlock looper continued in many parts of British Columbia. A virus disease attacking the looper population has made its appearance in several localities and is especially prevalent in the Caycuse and Nitinat regions. It is probable that in the older areas of infestation this disease will play an important part in reducing the outbreak. Special studies of the organism in question will be undertaken with a view to disseminating it artificially in regions where its presence has not been reported. Spraying of infested forests with DDT was undertaken by the B.C. Forest Service in co-operation with the industry. The officers of the Victoria laboratory directed the operations and checked the results. Approximately 12,500 acres were treated. During the first 24 hours, there was a heavy mortality especially among the younger larvae. The residual effects of the spraying persisted for about a week. Defoliation was noticeably reduced, but was not completely arrested. Better results would undoubtedly have been obtained if the application had been made at an earlier date. Nevertheless, information with regard to methods and procedure obtained in the course of the experiment will be of great value in future operations of this kind.

The control operations against the mountain pine bark beetle in the Banff National Park were discontinued in 1946. The combined effect of direct control measures and of increased precipitation warrant the belief that the menace to the Park has been definitely removed for the time being. However, close watch will continue to be kept over the area through regular surveys by the forest insect rangers and the park wardens. In Yoho Park, in the vicinity of Leanchoil, treatment of infested trees was resumed in January. Two hundred and eighty acres were cruised and a total of 1,909 trees were marked for felling and burning. By the end of March the greater part of the Leanchoil area had been treated but, owing to shortage of labour, it was impossible to complete the work as thoroughly as had been anticipated. However, subsequent cruises revealed the presence of only a very few infested trees. Experiments with poisons injected into the standing trees were only partially successful, and further work on this method will be undertaken in the near future. In general, it may now be stated that bark beetle control work in the Banff and Yoho National Parks has been eminently successful and that these valuable recreational areas

have been adequately protected from an infestation which might well have ended in total destruction. Inasmuch as the Bow River in the Banff National Park is the source of electric power for Calgary and vicinity, the protection of the forests on its watershed is a service of capital importance to this population centre.

Recent surveys of the lodgepole pine needle miner outbreak in Banff, Yoho, and Kootenay National Parks show a marked increase in the area affected. The infestation extends now over some 300 square miles. It is particularly heavy in the Lake Louise and Mount Eisenhower districts. Up to the present no trees have been killed, but some mature stands in the vicinity of Lake Louise have been seriously weakened. Whilst parasites attacking the miner have dropped to a low level, a microbial disease has recently made its appearance and has killed about 50 per cent of the larvae over a large part of the area. The possibility of using this disease organism in an attempt at speeding up the decline of the outbreak will be investigated during the coming season.

A survey of the insects affecting shade trees, shelterbelts and plantations in the park belt of the Prairie Provinces shows that the yellow-headed spruce sawfly was more destructive in 1946 than any other species. Spruce shelterbelts throughout the entire territory were attacked by this species and light to severe damage was caused to the trees in many localities. The balsam fir sawfly was reported for the first time as occurring in small numbers in Manitoba. The fall cankerworm was less abundant than in previous years. A high mortality in the egg stage of this pest was found to prevail. Pine needle scale was widely distributed and severe damage to spruce in many urban districts, particularly, was observed. The cecropia caterpillar was encountered over a wide territory in western Saskatchewan, but infestations were, in general, very light. The western willow leaf beetle, which had been very numerous over large territories in Alberta and Saskatchewan in 1945 and was expected to be even more serious in 1946, was on the whole less numerous and less widely distributed. A great reduction in the abundance of blister beetles was clearly indicated by the survey. Some species commonly found on trees and often very numerous and destructive were not observed.

Spray tests against pine needle scale were made at Indian Head, Sask. Among the many mixtures which were investigated, lime sulphur proved to be the most satisfactory for the control of the "crawling" and the early "settled" stages. Spraying with lime sulphur, DDT and benzene hexachloride against the later stages was ineffective.

Various concentrations of benzene hexachloride, DDT and pyrethrins were tested at Dahlton, Sask., for the control of the yellow-headed spruce sawfly. All 3 materials gave satisfactory control in the higher dosages, but DDT gave consistently the best results.

Systematic Entomology

The insect population of Canada is now known to consist of many thousands of different species of insects which are characterized by a great diversity in structure, habits, distribution, and degree of abundance. Officers engaged in problems of insect control, and investigators of other phases of insect activity are in constant need of information concerning the proper identification of the insects with which they are dealing. They also require information regarding the classification, habits, distribution and relative abundance of such insects. To provide this information and to ensure that it is accurate, timely, and as complete as possible, it is indispensible that a large, well organized reference collection of insects be maintained. The Canadian National Collection of Insects was established and is being developed to serve such needs.

During the past year officers of the unit have been actively engaged in supplying information of the above character to various officers of the Division of Entomology and to numerous other individuals engaged in problems relating to economic insects in various parts of Canada. A large amount of insect material has been identified for officers of the Division engaged in studies concerning orchard insects, particularly the pests of apple, cherry and peach. Many specimens have also been identified in connection with studies on forest pests, particularly the spruce and jack pine budworms, garden and field crops insects, and insects attacking foodstuffs and stored products. In addition, numerous specimens have been identified for officers of the Plant Protection Division in connection with interceptions from nursery stock, ornamental shrubs, and vegetable stock imported from other countries for propagation in Canada. Many requests for the identification of insect material and information concerning the habits and distribution of insects have also been received from officials of the Departments of Agriculture and Forestry in the various provinces, as well as from educational institutions, natural history societies and a large number of private individuals.

In addition to their other duties officers of the systematic unit have been actively engaged in carrying on studies designed to improve the classification of insects in the National Collection. Particular attention has been devoted to the orders Coleoptera (beetles), Diptera (two-winged flies), Lepidoptera (moths and butterflies) and Hymenoptera (sawflies, parasitic wasps, ants, bees, etc.). In these groups the various specialists concerned have rearranged portions of the collection to conform with modern systems of classification. In the course of such work much previously unstudied material has been critically examined and classified. Original studies have been undertaken in certain groups, particularly the wireworms (Elateridae), leaf feeding beetles (Chrysomelidae), budworms (Tortricidae), casebearers (Coleophoridae), cutworms (Phalaenidae), parasitic wasps (Chalcidoidea and Ichneumonoidea) and various groups of flies (particularly the families Tabanidae, Sapromyzidae and Larvaevoridae). These studies have resulted in the discovery of a number of species previously unknown to science and several papers describing these new forms and dealing with problems of classification have been prepared.

As a part of a co-operative project with the Forage Plants Division of this Department in respect to insect problems in relation to alfalfa seed production in northern Saskatchewan this unit published an extensive report dealing with the relations of wild bees to the alfalfa seed problem, based on field work undertaken in northern Saskatchewan in 1944. This report, which contains many items of basic importance to the alfalfa seed production problem, has been received with great interest on the part of other investigators and should prove of much value in future studies on this subject.

During the summer of 1946 field studies were carried on in the Annapolis Royal area of Nova Scotia, at Ste. Agathe, Quebec, and in the Ottawa, Ontario, district, including the nearby points of Bristol and Wakefield, Quebec, for the purpose of obtaining specimens and data for the National Collection of Insects. During the winter in addition to studies at headquarters officers of the Unit visited museums at Boston, New York, Philadelphia and Washington, for the purpose of studying insect collections and reference libraries and to consult with various specialists in insect taxonomy located at these centres.

Stored Product Insect Investigations

The most outstanding contribution during the year has been the improvement effected in connection with the control of spider beetles. These insects are important pests of flour and cereal products in storage in Canada and

various species are involved in different parts of the Dominion. The most common and widespread losses have occurred in the Prairie Provinces where these insects have been present for a considerable period of time. Through the use of DDT, benzene hexachloride, or magnesium oxide, it is now possible to secure practically complete control of these pests by a single application of the insecticide in flour warehouses during late spring and early summer. The application of the insecticide is timed to coincide with the peak emergence of the adult beetles. A motion picture film in colour was prepared in connection with the control of these pests and was used widely during the spring of 1947 in the education of flour milling company personnel in improved methods of control.

Insects infesting grain have been of considerably less importance than during the war years. Close contact is still maintained with the grain trade to render assistance whenever it is necessary. Minor infestations of the rust-red grain beetle and mites still occur in some lots of grain. These may be controlled by fumigation with chloropicrin or carbon tetrachloride.

A survey of conditions in the large flour mills throughout Canada during 1946 showed a great variation in the attention devoted to insect control and in the methods employed. The survey indicates the necessity for supplementary control measures between general fumigations.

A survey of the plants making spray-type milk powder in Ontario revealed that most of them were in excellent condition. The most common insect encountered was one of the carpet beetles which constitutes a problem in connection with the storage of the product in certain of the older plants.

The tobacco moth has caused some infestation in Ontario tobacco warehouses but the infestations were reduced considerably by the use of a residual type spray of DDT supplemented by space sprays.

Assistance has been rendered to seed stores, flour mills, and grain elevators of all types in connection with their insect problems.

Close contact has been maintained with the Board of Grain Commissioners who have been kept informed regarding the entomological conditions in grain storage facilities throughout the Dominion.

Biological Control of Insects

Parasites have been distributed during the year in connection with the following insects: codling moth in British Columbia; European corn borer in Ontario, Quebec and New Brunswick; European larch sawfly in Newfoundland; pine sawflies in Ontario, Quebec and Manitoba; European spruce sawfly in Ontario, Quebec, Maritime Provinces and Newfoundland; the yellow headed spruce sawfly in Manitoba and Ontario; the hemlock sawfly in British Columbia; grasshoppers of various species in Ontario and Alberta; the greenhouse whitefly in all provinces of Canada; the orchard mealybug in British Columbia; the Oriental fruit moth in Ontario; the larch casebearer in Ontario, Quebec, the Maritime Provinces and Newfoundland; the spruce budworm in Manitoba, Ontario, Quebec and New Brunswick; the pea moth in Quebec, New Brunswick, Nova Scotia and Prince Edward Island; and Comstock's mealybug in Ontario.

The spruce budworm was given a great deal of attention during the year. Collection of parasites in British Columbia was continued and propagation of two important species was carried out at the Belleville laboratory. Arrangements were completed during the winter for investigations in Europe by the Imperial Bureau of Biological Control and it is hoped that both insect parasites and disease organisms will be obtained that will aid in the control of this most serious pest. Parasite liberations were made during the year at carefully selected locations in Manitoba, Ontario, Quebec and New Brunswick. One parasite species obtained from British Columbia in 1944 was recovered in some numbers

from the liberation area in Ontario during the summer of 1946. Investigations carried out at the laboratory at Parke Reserve, Quebec, provided extremely useful information on the value of introduced parasites of the spruce sawfly. One of the introduced species continued to increase its effectiveness very markedly and nearly 50 per cent of the larvae collected over an area of 30 square miles were killed by this parasite. Another introduced parasite released in small numbers 12 years ago was recovered for the first time in this area, indicating that it sometimes requires several years for introduced parasites to build up in sufficient numbers to be turned up in recovery studies.

Parasites of the European larch casebearer introduced from Europe have now become well established at a number of points in Ontario and Quebec, and material collected locally was used during the year for redistribution of the parasites throughout the Eastern Provinces and Newfoundland. At points where the parasites have been established for 3 to 5 years, the casebearer infestation has been very markedly reduced. It is felt that when the parasites are generally distributed over Eastern Canada there will be a marked reduction in this pest which is now a serious threat to the young larch stands.

The greenhouse industry received assistance through distribution of the parasite of the greenhouse whitefly which was propagated at the Belleville laboratory. This parasite was obtained from England nearly 20 years ago and has proved a very effective control for the greenhouse whitefly, thus contributing greatly to reducing the cost of production of tomatoes and cucumbers grown under glass. The parasite has also been used effectively in experimental greenhouses of the Department of Agriculture and in conservatories and small greenhouses where fumigation cannot be carried out with safety.

During the summer of 1946 a survey was made in British Columbia of the results of several parasite introductions, and the information obtained showed that these have been of great value to the industries concerned. Parasites of the pea moth obtained from England and colonized in British Columbia between 1937 and 1940 have now built up populations sufficient to bring about a reduction in pea moth infestation, and during 1945 and 1946 large collections of material made in the Lower Fraser Valley were used for distribution of the parasites in Quebec and the Maritime Provinces. The orchard mealybug which was, at one time, an extremely serious pest on apple trees in British Columbia, has been greatly reduced as a result of parasite introduction, and following last year's survey arrangements will be made for further distribution of these parasites with a view to making control more generally effective. The propagation and distribution of codling moth parasites obtained from Europe was continued during the year and liberation of two species was made at a number of points in the Okanagan Valley of British Columbia. This work is being continued and liberations will be made at other points in British Columbia and in the Eastern Provinces as material becomes available. Propagation of Oriental fruit moth parasites was again undertaken after a lapse of several years and an experiment planned to cover a five-year period was initiated in connection with the use of parasites for control of this pest in southwestern Ontario.

Introduced parasites of the European corn borer continued to increase in Ontario and a number of liberations were made during the season in Quebec and New Brunswick.

As a result of the continued investigations of the Imperial Bureau of Biological Control in South America two species of grasshopper parasites were received during the year and releases were made in Ontario and Alberta. Investigation of parasites and other natural enemies of grasshoppers in various parts of Canada was continued and the information obtained continues to indicate some relationship between the grasshopper populations and parasite abundance, thus suggesting the probable value of transfer or manipulation of parasites in

the biological control of these pests. These investigations are complicated by the fact that so many different species of grasshoppers are involved, very careful and detailed studies over a long period of years will be essential.

Livestock Insect Investigations

Primary attention was given in 1946-47 to warble fly control. At the Kamloops laboratory emphasis centred upon the life history and habits of the two species of warble flies that are native to Canada. Hundreds of naturally emerged grubs were collected by a special technique and it was found that the emergence pattern of the two species differed between regions of different climate. Such information is extremely important in the proper timing of control measures. The warble fly control campaign in Western Canada again was directed from the Lethbridge laboratory. Over 1,000,000 head of cattle in the Prairie Provinces were treated for warbles during the year. At least half of these were sprayed by means of power machines of which there are now more than 150, privately owned, employed for this purpose. The results have been most gratifying. Careful examination has revealed that in some ranches, after three years of treatment, the number of grubs per animal has been reduced from an average of 30 to 40 to as low as 5 to 6. The power sprayers that are used for warble control are being increasingly employed for many other purposes such as spraying for weed control, spraying of barns and other buildings for the control of houseflies, spraying sheep for the control of sheep ked, and spraying of cattle for the control of lice and biting flies.

One of the outstanding contributions to the livestock industry in British Columbia made by the laboratory at Kamloops is the discovery that benzene hexachloride appears to be the long sought tick repellent. Cattle sprayed with this material appeared to be protected from the paralysis tick during its period of activity and there is every promise that animals so treated can be turned out to early pastures without fear of loss by ticks. Annual studies on the feeding rates of ticks and the production of tick paralysis in laboratory-infested sheep have yielded interesting data on the etiology of this strange disease.

Studies on the control of cattle lice, poultry mites, and sheep keds were continued at Kamloops and promising results were obtained with the use of DDT and benzene hexachloride. Both of these chemicals are very effective against keds and progress has been made in applying them by means of a spray boom through which sheep are driven.

In Ontario, observations were made upon the use of power sprayers for the treatment of cattle in barns. Mechanical devices for the disinfestation of hogs and cattle were also inspected.

Since DDT has been demonstrated to be very effective against several pests of livestock, the known facts were summarized in a 7500-word publication for the guidance of producers and of professional workers.

Household and Medical Entomology

Various chemical formulations and methods have been developed for combating the many insect pests affecting man and his household. Of the several outstandingly effective new insecticides now available, DDT is coming into increasingly widespread use. Methods of using this chemical to best advantage have been given wide publicity, and there are indications that the public have benefited materially from these recommendations in reducing trouble from pests in dwellings, hotels, food stores, hospitals and other buildings.

The prolonged residual effectiveness of DDT deposits from oil solutions and water suspensions, sprayed on various surfaces in quantites comparable

with those recommended and used under practical conditions, is being studied under controlled laboratory conditions. In the tests carried out, some of the deposits on the less absorptive surfaces have continued to kill house flies that come in contact with them over a period of more than 18 months after the material was applied. The remarkable effectiveness of 5 per cent DDT residual sprays in controlling infestations of flies, fleas and bedbugs, and the practicability of ridding premises such as homes, hotels, hospitals, food establishments, and industrial buildings of cockroaches by means of dusts containing 10 per cent DDT and 10 per cent pyrethrum powder has been further demonstrated. The latter mixture is now being used successfully in the control of head lice infesting children in schools.

Preliminary tests, under practical conditions, of benzene hexachloride (666) have shown that small percentages (fractions of 1 per cent) of the gamma isomer in kerosene solution readily kill German cockroaches and the brown dog tick, the latter being a newly established pest in several cities and other localities in Eastern Canada. A 1 per cent solution of chlordane (1068) was found to be effective in controlling cockroaches when sprayed in their haunts and hiding places.

Mosquito control has progressed with the arrival of the newer insecticides, and it has been shown that control is practical with as little material as 1 gallon of 1 per cent DDT or 1½ ounces of gammexane per acre. Airplane and turbine dusters were tested for this work. Control from the air holds considerable promise, but there are still many obstacles to overcome pertaining mainly to the nature of terrain, brush and reed coverage over pools, and possible effect on fish and wildlife. At present, the Kamloops laboratory is directing mosquito control in 8 British Columbia cities and communities.

Flea studies were continued and the identification of specimens collected during the Provincial Health Department Plague Surveys of British Columbia, Alberta and Saskatchewan again gave information of great value. Climaxing eight years of study and collecting, an extensive monograph has been prepared upon the 124 known species of fleas in Canada.

Close contact has been maintained with the insecticide and pest control industries and with public health authorities. Information and advice regarding various pests and their control have been distributed widely.

The Canadian Insect Pest Survey

Systematic recording of the occurrence, distribution, and importance of insect pests in Canada was continued during 1946. The organization of the material in the Canadian Insect Pest Review was improved and publication was changed from a bi-monthly to a monthly basis. By this means workers throughout the Dominion are kept informed of the seasonal changes occurring in the insect pest situation.

Insecticides Registration and Advisory Service

During the year, officers of the Division of Entomology reviewed the formulae, claims and directions of many hundreds of proprietary insecticide preparations submitted for registration for sale in Canada under the Pest Control Products Act, thus ensuring high standard insecticide products for the Canadian public. This work has become especially important during the past several years because of the many new developments in the insecticide field during the war and post-war periods. Through publications, correspondence and personal interviews the insecticide industry has been greatly assisted in the development of formulations and knowledge of methods of using the

newer insecticidal chemicals. Several publications summarizing the latest available information on the new insecticides and their uses were prepared and distributed during the year.

Publications

In addition to the list of technical papers given at the beginning of the Science Service report, the Division of Entomolgy published some 50 popular articles in the form of control statements, reports to industrial groups, and specially prepared press items.

DIVISION OF PLANT PROTECTION

This Division is responsible primarily for the administration of the Destructive Insect and Pest Act and the regulations formulated thereunder. The Act was passed in 1910. Since that time, twenty-two foreign and twelve domestic regulations have been established to prevent the introduction of injurious insects and diseases on plant material. One export regulation was passed in 1932, covering the export of apples to countries other than the United States.

The procedure governing the importation of nursery stock, which includes plants or portions of plants for propagation, except seeds and seed potatoes, is briefy as follows:

1. A permit, procured from Ottawa, must be presented to Customs by importers, when obtaining release of consignments.
2. All shipments to Canada must be accompanied by a certificate of inspection, issued by an authorized inspector in the country of origin, declaring the contents to be apparently free from insect pests and plant diseases.
3. Such importations are subject to re-inspection in Canada, and to treatment or destruction, if necessary.
4. Interceptions of insects or diseases, not readily identifiable by the inspection staff, are referred to specialists in the Divisions of Entomology, and Botany and Plant Pathology.
5. All importations must be routed through one of the established ports in Canada.

Plant Inspection staffs are maintained at the following points: Halifax, N.S.; Saint John, N.B.; Quebec and Montreal, Que.; Ottawa, Toronto, Niagara Falls, London and Windsor, Ont.; Winnipeg, Man.; Estevan, Sask.; Vancouver and Victoria, B.C.

The certification of seed potatoes started in the Maritime Provinces in 1915. Since that time the standards have been steadily raised and the work extended to every province in the Dominion. In 1938, this service became a responsibility of this Division and includes:

1. The establishment of standards governing production.
2. The supervision of production and shipment by inspection in the field, in storage, and at shipping point.
3. The development and supervision of tuber indexing and tuber units to improve and multiply foundation stock.
4. The issuance of official tags conforming to Canadian Certified seed potato standards.
5. Advice to growers on modern methods of seed potato production.

Certified Seed Potato Inspection staffs are stationed at Charlottetown, P.E.I.; Kentville, N.S.; Fredericton, N.B.; Ste. Anne de la Pocatiere, Que.;

Ottawa, London, Guelph, and Barrie, Ont.; Winnipeg, Man.; Estevan, Sask.; Edmonton, Alta.; Vancouver and Victoria, B.C.

Plant Inspection

The activities connected with Plant Inspection, during the year ended March 31, 1947, are summarized as follows:

Imports of Plants.—There were 53,387,858 bulbs, 21,000,000 corms and cormels, and 896,916 plants, or a grand total of 75,284,774 plant units, valued at $1,843,977, imported from 19 different countries in 72,172 containers, under 6,946 standard and 725 emergency permits, requiring 7,367 separate inspections, of which 2,320 dealt with parcel post importations, involving 185,091 plants, bulbs, etc.

Sixty importations of plant material, comprising 29,669 plants and 14 pounds of seed potatoes, were refused entry because of infraction of regulations under the Destructive Insect and Pest Act.

Inspection of Passengers' Baggage.—This activity applies chiefly at the ocean ports, where a total of 2,488 boats, including freight boats, were attended, and 25 passengers were found to have 946 plants and 2 pounds of plant products in their possession; the latter was prohibited entry for lack of special certification. The inspection staff works closely with the Customs officers in carrying out these duties.

At Windsor and Niagara Falls similar co-operation is provided and recently arrangements were made to assist Customs at other major Canadian and United States border crossing ports. Where an inspector of the Plant Protection Division is not located, regulations of the Destructive Insect and Pest Act are administered by Customs officers. Plants being imported at such ports, and not prohibited by regulation, may be directed through an authorized port of importation for inspection.

Introduction of Live Insects, etc.—During the year, 73 permits were issued, under Regulation No. 21 (Foreign), covering the importation for investigational and experimental purposes of various stages of insects, insect parasites, bacterial or fungus cultures, and plant diseases.

Imports of Plant Products.—There were 3,620 inspections made of plant product imports from 26 countries, involving 2,448,765 containers. In 15 instances, shipments prohibited by regulation were seized, 14 of which were destroyed, and 1 returned to the shipper.

Exports of Plants and Plant Products.—Nursery stock, etc., was inspected and certified for export to 32 countries, totalling: 963,354 plants; 8,114,690 bulbs, corms and cormels; and 2,110 lb. of tree and miscellaneous seeds. Plant products certified as a requirement of the country of import, were exported to 39 countries, and consisted of: 24,879,530 lb. of table stock potatoes; 4,118,584 bushels of apples; 4,720,232 lb. of seed corn; 3,654,890 lb. of vegetable and cereal seeds; 99,530 lb. of dried hops; 60,000 lb. of feed oats; 5,000 lb. of edible onions; 51,748 lb. of cotton waste; 17, 285 Christmas trees; and 331,668 stems of bananas (in co-operation with and at the request of the United States Department of Agriculture).

Interceptions—The number of interceptions of insects and diseases taken on imported plants and plant products was 542, none of which was new to Canada, except the durra stem borer (*Sesamia cretica* Lederer), found in broom corn imported from Italy. This insect is known to be a serious pest of maize and sorghum plants in countries bordering the Mediterranean Sea.

Protection of Food Products.—The inspection service has been extended gradually to cover an increasing range of plant products. Large importations from various countries of the world have been found infested with insects, and frequently fumigation or cold storage treatment has been required.

Stored Product Inspections and Investigations.—Efforts were continued to safeguard food products from serious insect damage and consequent loss, through the inspection of boats, elevators, flour mills and dehydrating plants. During the past shipping season, 266 boats were examined at seaboard ports before being loaded with grain and cereal products for overseas shipment, and 39 of these carriers required the application of clean-up measures; 90 boats were also examined at the Lakehead, previous to taking on cargoes of grain for winter storage, and 44 required cleaning. In addition, all terminal elevators and a number of flour mills were inspected where insects occurred or were suspected. Co-operation was received from the Board of Grain Commissioners and the Division of Entomology in the inspection of elevators, and assistance was supplied by the Fruit and Vegetable Division in the examination of dehydrating plants.

Montreal Fumigation and Research Laboratory—During the year activities included the direction of operations connected with the fumigation, in railway box cars, of many tons of baled Italian broom corn, for the control of corn and stem borers; the treatment of large shipments of peanuts from Algeria and Egypt, infested with stored-product insects; the commercial fumigation of such infested commodities as Turkish and Java tobaccos, seed corn, seed peas, shelled and unshelled walnuts, cotton bags, mattresses, etc. Experiments were conducted on the treatment of second-hand potato bags to prevent the spread of bacterial ring rot; the analysing of samples of sugar collected before and after fumigation to determine if bromide residues were present; and the treatment of infested dried rennet without affecting essential enzymes. The laboratory staff has continued research investigations throughout the year on potato-rot nematode and the residual effect of DDT solutions in the control of houseflies.

Field Projects

The main field projects carried on in 1946 with the object of determining the distribution, suppression and control of destructive insect pests were as follows:

Apple Maggot—This insect is a native of North America and occurs in all the fruit growing areas of Ontario, Quebec, and the Maritime Provinces. It is not known to be established in Europe and on this account special precautionary measures are undertaken each year by co-operating government agencies to safeguard and maintain the apple export trade. Pre-harvest surveys were conducted in Nova Scotia and New Brunswick, and a partial survey in Ontario, in 1946 in co-operation with the provincial governments concerned. Varieties found free from maggot, during the survey and subsequent packing-house inspections, may be certified for export, provided the identity of the fruit can be duly confirmed as originating in orchards where the required control measures have been carried out by the growers under government supervision.

Because of the extremely light crop in 1945, when only partial surveys were made, it is impossible to compare the 1946 results with those of the previous year.

European (Dutch) Elm Disease—This destructive disease of elms, first observed in Holland in 1919, and in the United States in 1930, was found in the province of Quebec in 1944 by the Quebec Department of Lands and Forests.

Previously realizing the danger of introducing this disease into Canada on nursery stock, Regulation No. 17 (Foreign) of the Destructive Insect and Pest Act was passed in 1928, prohibiting the importation of elms from Europe. The regulation was amended in 1934 to prohibit the importation of all species and varieties of the genera *Ulmus* and *Zelkova*, including logs or burls, from all countries.

In 1945, an Order in Council was passed establishing Regulation No. 12 (Domestic) under the Destructive Insect and Pest Act, to control the movement of elm and elm products from areas found to be infected.

Extensive co-operative scouting was conducted in Quebec and Ontario in 1946. Suspected specimens were forwarded to the Provincial Laboratory of Forest Pathology at Quebec, or to the Dominion Laboratory of Plant Pathology at Ottawa, for examination and culture. No signs of the disease were found in Ontario, but 2,114 trees were found to be infected in Quebec. Trees were found to be infected in six additional counties during the year, and since the disease was first located in 1944 it has been found in 30 counties. The greatest number of infected trees was found in Richelieu county, and the disease has been found from Vaudreuil county in the west to Quebec county in the east.

All trees found infected during 1944 and 1945 were removed and disposed of by the owners, public utility companies, and the municipalities concerned, by the end of May, 1946.

A similar program, covering removal of trees found infected in 1946, was carried on during the fall and winter of 1946-47, and at March 31, 1947, 1,342 trees had been felled and a proper disposal made of the wood.

Strenuous efforts will be made in future seasons to hold this outbreak in check and to retard its spread to other areas.

Japanese Beetle—This insect, a native of Japan, was first discovered on this continent in 1916, near Riverton, New Jersey. Since 1927, special precautions have been carried out by members of this Division to prevent its introduction into Canada, but in spite of these precautions, the first outbreak was discovered at Niagara Falls, Ontario, in 1940

From 1942 to 1946, inclusive, between seven and eight thousand traps have been operated annually in Ontario, Quebec, and the Maritime Provinces, with the majority of the traps being placed at points in southern Ontario. In Ontario, the Provincial Department of Agriculture assisted in the trapping operations by providing annually, 30 to 35 members of the Farm Service Force to act as trap attendants. Approximately 2,500 Japanese beetles have been trapped or taken in scouting during this five-year period.

From 1942 to 1944, 265 acres were treated with lead arsenate in Ontario at points where large numbers of beetles were captured, and in 1946, 17·5 acres were treated in the City of Hamilton. In 1945, 4·5 acres were treated at Halifax, N.S. The total acreage treated to date for Japanese beetle control now amounts to 287 acres.

Co-operation in this work has been received from the Ontario Agricultural College, the Ontario Fruit Branch and Farm Service Force, the Nova Scotia Department of Agriculture, the park and civic authorities in the cities where soil treatment was applied, and the Division of Entomology of this Department.

The question of placing a quarantine on the infested areas in Ontario has been discussed, but it does not appear advisable or necessary to take such action at present. Every consideration has been given, therefore, to concentrated efforts toward keeping the known infestations under control and applying treatment to new infestations, should they occur.

Oriental Fruit Moth.—This insect, which is a very destructive pest of peaches and other soft fruits, was introduced into eastern North America from Japan, at least thirty years ago. It has become well established in the peach

growing areas of eastern Canada and the United States, and, more recently, has spread to the Pacific coast States. A number of specimens were trapped at several points in the State of Washington in 1945, and anxiety was felt by government agencies and fruit growers' organizations in British Columbia regarding its possible appearance in that Province.

The United States Department of Agriculture co-operated very fully in the survey of peach orchards in southern British Columbia in 1946, by supplying nearly 400 special type traps and certain bait materials. The traps were placed and examined regularly by officers of this Division during an eight-week period in mid-summer, but no signs of the pest were found.

It is proposed to carry on this survey again this year in order that incipient outbreaks may be adequately dealt with, should they be located.

Other field projects carried out during the season included European earwig scouting in Toronto, the grader inspection of apples for scale insects in British Columbia, and a limited amount of trapping for the pear psylla in the lower Fraser Valley in British Columbia.

The European earwig scouting in Toronto was done at the request of the Provincial Entomologist of Ontario, following complaints received from residents of the area infested. The area infested covers a few blocks in the central section of the city, and it is the understanding that provincial officials will apply suppressive measures during 1947.

The limited pear psylla work done in British Columbia was conducted in co-operation with the United States Department of Agriculture. The grader inspection of fruit for scale insects in a number of packing houses in the southern half of the Okanagan Valley has been carried on for three years in co-operation with the Provincial Department of Agriculture and B.C. Tree Fruits, Ltd. Results of the scale insects survey have been made available to the co-operating agencies, with recommendations that a serious effort be made to apply efficient control measures in the infested areas.

Seed Potato Certification

In 1946, a greater acreage of potatoes was entered for inspection than ever before, exceeding the entries in 1945 by over 17,000 acres. Eighty-two per cent of the acreage entered passed. Over 3,750,000 bushels of Foundation and Foundation A seed were produced in 1946 out of an estimated total of 10,750,000 bushels. This is an increase of 4,000,000 bushels in total production over 1945. Tuber indexing was continued in various greenhouses during the winter months, to aid the growers in the selection of disease-free seed for planting in tuber units.

In 1946, 7,896 growers entered for certification 67,343 acres, of which 55,256 passed field inspections. This is an increase of approximately 15,000 acres over 1945. The acreages passed of the main varieties were: Irish Cobbler, 16,041; Green Mountain, 14,876; Katahdin, 12,367; and Sebago, 6,605. Total production increased from 6,501,040 bushels in 1945 to 10,855,400 bushels in 1946.

Shipments.—Shipments from the 1945 crop totalled 4,818,651 bushels, of which 2,497,620 bushels were exported, and 2,321,031 bushels were sold in Canadian markets. The principal importing countries were: United States, 1,702,817 bushels; Cuba, 311,154 bushels; Argentina, 109,846 bushels; Uruguay, 92,400 bushels; South Africa, 91,994 bushels; Venezuela, 86,511 bushels; and Newfoundland, 46,112 bushels. The principal exporting provinces were: Prince Edward Island, 1,623,000; and New Brunswick, 788,716 bushels.

Shipments from the 1946 crop to March 31, 1947, totalled 3,262,876 bushels, of which 2,706,554 bushels were exported and 556,322 bushels were shipped to domestic markets. The principal foreign markets were: United States, 1,566,212 bushels; Argentina, 425,832 bushels; Cuba, 293,806 bushels; Uruguay, 182,420 bushels; South Africa, 96,934 bushels; and Venezuela, 79,211 bushels.

The United Kingdom has prohibited the importation of potatoes from North America for many years on account of Colorado potato beetle. During the year, however, because of food shortages, an order was placed for approximately 3,000,000 bushels. These potatoes were all shipped from Prince Edward Island, and consisted of approximately 70 per cent certified seed, which was sold as table stock. While Colorado potato beetles have never been found in graded and packaged potatoes, inspectors of the Plant Protection Division checked all these potatoes for this insect, and for bacterial ring rot.

Foundation Seed.—Foundation seed continues to be on the increase. In 1946, crops from 3,511 acres were eligible for Foundation tags, as compared with 2,640 acres in 1945.

Foundation A Seed.—In 1946, crops from 19,200 acres were eligible for Foundation A tags, with a total estimated production of 3,226,100 bushels. This is 1,000,000 bushels more than the quantity produced in 1945.

Production.—Total production of graded stock in 1946 has been estimated at over 10,750,000 bushels, of which 612,400 were eligible for Foundation tags, 3,250,000 for Foundation A tags, and over 7,000,000 bushels for Certified tags.

Tuber Indexing.—Tuber indexing was carried out as in previous years. The Department maintains greenhouses in the three Maritime Provinces. In Quebec, two large greenhouses at Ste. Anne de la Pocatière, built by the Provincial Government, are used for indexing work, and in the winter of 1946-47 over 40,000 tubers were indexed there. The indexing work in the other provinces is carried out in co-operation with the Provincial Departments and the University officials.

International Plant Legislation

The Plant Regulations maintained by foreign countries are studied and summarized. Copies of the resultant instructions are distributed to staffs throughout the Dominion for their information and guidance in certifying shipments of plants and plant products from Canada.

DIRECTORY OF SCIENCE SERVICE OFFICES AND LABORATORIES

Director, Science Service—Records Bldg., Ottawa

Nova Scotia

Dominion Laboratory of Plant Pathology (Fruit and Vegetable Diseases)	Kentville
Dominion Agricultural Chemistry Laboratory	Kentville
Dominion Entomological Laboratory (Fruit and Vegetable Insects)	Annapolis Royal
Plant Inspection	Dominion Public Bldg., Halifax
Seed Potato Certification	Experimental Station, Kentville

Prince Edward Island

Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Charlottetown
Dominion Entomological Laboratory (Field Crop and Vegetable Insects)	Charlottetown
Seed Potato Certification	Laboratory of Plant Pathology, Charlottetown

New Brunswick

Dominion Laboratory of Plant Pathology (Potato Viruses; Field Crop, Fruit, and Vegetable Diseases)	Fredericton
Dominion Entomological Laboratory (Forest, Field Crop, Vegetable and Fruit Insects)	Fredericton
Plant Inspection	Customs Bldg., Saint John
Seed Potato Certification	Customs Bldg., Fredericton

Quebec

Division of Animal Pathology (Administration, Animal Pathology, Poultry Pathology, Biological Products, Parasitology, and Laboratory Services)	Hull
Animal Parasitology	Institute of Parasitology, Macdonald College
Dominion Laboratory of Plant Pathology (Fruit, Field Crop, and Vegetable Diseases)	Ste Anne de la Pocatiere
Dominion Entomological Laboratory (Fruit Insects)	Hemmingford
Dominion Entomological Laboratory (Vegetable Insects)	St. Jean
Seed Potato Certification	P.O. Building, Ste Anne de la Pocatiere
Plant Inspection	2 Avenue Chauveau, Quebec
Plant Inspection	105 McGill St., Montreal
Fumigation Station	785 Mill St., Montreal

Ontario

Poultry Pathology Laboratory	Central Experimental Farm, Ottawa
Division of Bacteriology and Dairy Research (Administration, Dairy Research, Food Microbiology, Soil Microbiology, and General and Analytical Bacteriology)	Central Experimental Farm, Ottawa

Division of Botany and Plant Pathology (Administration, Agricultural Botany, Systematic Botany, Dominion Arboretum, Herbarium, Mycology, Forest Pathology, Fruit and Vegetable Diseases, Seed-Borne Diseases, and Plant Physiology)	Central Experimental Farm, Ottawa
Dominion Laboratory of Forest Pathology	Univ. of Toronto, Toronto
Dominion Laboratory of Plant Pathology (Fruit, Field Crop, and Vegetable Diseases)	St. Catharines
Dominion Laboratory of Plant Pathology (Special Crop and Vegetable Diseases)	Harrow
Division of Chemistry (Administration, Food Chemistry, Soil Chemistry, Animal Nutrition, Plant Chemistry and Vitamin Assays)	Central Experimental Farm, Ottawa
Division of Entomology (Administration, Field Crop Insects, Forest Insects, Systematic Entomology and National Insect Collection, Stored Product Insects, and Insects of Household and Man)	Records Bldg., Ottawa
Dominion Entomological Laboratory (Forest Insects)	Sault Ste. Marie
Dominion Parasite Laboratory (Propagation and Liberation of Parasites of Destructive Insects)	Belleville
(The Common Bureau of Biological Control of Farnham Royal, England, operated under the Commonwealth Agricultural Bureau, has been transferred to Belleville.)	
Dominion Entomological Laboratory (Fruit Insects)	Vineland Station
Dominion Entomological Laboratory (Field Crop and Vegetable Insects)	Chatham
Dominion Entomological Laboratory (Fruit Insects)	Simcoe
Plant Protection Division (Administration, Plant Inspection, and Seed Potato Certification)	Records Bldg., Ottawa
Plant Inspection	21 Lombard St., Toronto
Seed Potato Certification	Ontario Agricultural College, Guelph
Plant Inspection	Federal Bldg., Niagara Falls
Plant Inspection and Seed Potato Certification	Dominion Public Bldg., London
Plant Inspection	Canada Building Windsor
Seed Potato Certification	Barrie

MANITOBA

Dominion Laboratory of Plant Pathology (Field Crop, Vegetable, and Seed-Borne Diseases)	Winnipeg
Dominion Entomological Laboratory (Forest Insects)	Winnipeg
Dominion Entomological Laboratory (Field Crop, Fruit and Vegetable Insects)	Brandon
Dominion Entomological Laboratory (Stored Product Insects)	Dom. Public Bldg., Winnipeg
Plant Inspection and Seed Potato Certification	Dom. Public Bldg., Winnipeg

SASKATCHEWAN

Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Saskatoon
Dominion Entomological Laboratory (Field Crop and Vegetable Insects)	Saskatoon
Dominion Entomological Laboratory (Forest and Shade Tree Insects)	Indian Head
Plant Inspection and Seed Potato Certification	P.O. Bldg., Estevan

Alberta

Dominion Veterinary Research Station	Lethbridge
Dominion Laboratory of Plant Pathology (Field Crop and Vegetable Diseases)	Edmonton
Dominion Entomological Laboratory (Field Crop, Vegetable and Livestock Insects)	Lethbridge
Seed Potato Certification	408 Blowey-Henry Bldg., Edmonton

British Columbia

Dominion Animal Pathology Laboratory	Saanichton
Dominion Laboratory of Plant Pathology (Fruit and Vegetable Diseases)	Summerland
Dominion Laboratory of Plant Pathology (Fruit, Ornamental Plant, Vegetable and Seed-Borne Diseases)	Saanichton
Dominion Laboratory of Plant Pathology (Vegetable and Fruit Diseases)	University of British Columbia, Vancouver
Dominion Laboratory of Plant Pathology (Forest Diseases)	Belmont Bldg., Victoria
Dominion Agricultural Chemistry Laboratory	Summerland
Dominion Entomological Laboratory (Fruit Insects)	Summerland
Dominion Entomological Laboratory (Forest Insects)	Vernon
Dominion Entomological Laboratory (Live Stock Insects)	Kamloops
Dominion Entomological Laboratory (Field Crop and Vegetable Insects)	Kamloops
Dominion Entomological Laboratory (Field Crop, Fruit and Vegetable Insects)	Agassiz
Dominion Entomological Laboratory (Field Crop, Fruit and Vegetable Insects)	Parliament Bldg., Victoria
Dominion Entomological Laboratory (Forest Insects)	Central Bldg., Victoria
Plant Inspection and Seed Potato Certification	Federal Bldg., Vancouver
Plant Inspection and Seed Potato Certification	Parliament Bldg., Victoria
Bacterioligical Laboratory	Summerland

Ottawa: Printed by Edmond Cloutier, C.M.G., B.A., L.Ph., Printer to the King's Most Excellent Majesty, 1948.